Autopower

AUTOPOWER

This little book is dedicated to those thousands of tinkerers who while away their leisure hours fashioning useful things to make their working hours more enjoyable. It has not been written to take the place of the many good text books that may be purchased covering each of its chapters in minute detail. It is intended to help that great group of men who, through the power of their minds and the skill of their hands, are able to take discarded and practically worthless leftovers of this mechanical age and transform them into bright and shining tools for everyday use.

"Give instruction to a wise man, and he will be yet wiser: teach a just man, and he will increase in learning."

Proverbs IX:9.

Revised Edition
Copyright 1949
By AUTOPOWER INCORPORATED
918 S. Theresa Ave.
ST. LOUIS 3, MO.

CONTENTS

CHAPTER I

Page

Alternating Current Generators 1

General—Stripping of the Armature in Preparation for Rewinding

1. 100 Watt Continuous Duty or 200 Watt Short Time Duty using Model T Ford Generator, 110 volt, 60 cycle, 1800 R.P.M.
2. 100 Watt Continuous Duty or 200 Watt Short Time Duty using Ford Powerhouse Generator, 110 volt, 60 cycle, 1200 R.P.M.
3. 300 Watt using Delco Starter Generator with original generator winding for self excitation, 110 volt, 60 cycle, 1800 R.P.M.
4. 500 Watt using Delco Starter Generator with new winding for self excitation, 110 volt, 60 cycle, 1800 R.P.M.
5. 500 Watt using North East Type G or GA with self excitation, 110 volt, 60 cycle, 1800 R.P.M.
6. 500 Watt using Delco 500 Watt 32 volt Farm Light Plant self excited, 110 volt, 60 cycle, 1800 R.P.M.
7. 100 Watt using Delco Remy or Autolite 14 slot Generator, separately excited, 110 volt, 60 cycle, 3600 R.P.M.

CHAPTER II

Direct Current Generators 12

1. **32 Volts D.C.**
   a. 150 watt using Model T Ford Generator
   b. 300 watt using Delco Starter Generator
   c. 500 watt using North East Type G or GA Generator
2. **110 Volt D.C.**
   500 watt using North East Type G or GA Generator
3. **400 Volt D.C.**
   100 watt using Ford Powerhouse Generator
4. **1000 Volt D.C.**
   500 watt using North East Type G or GA Generator
5. **Characteristics of D.C. Generators**
   Slow Speed D.C. Generators
   North East Type G or GA Generator
   Delco Starter Generator

CHAPTER III

Motors 21

1. ¼ HP, 110 volt, 60 cycle A.C. using North East Type G or GA generator.
2. 6 volt D.C. motor using Model T Ford Generator
3. 32 volt D.C. motor using Model T Ford Generator
4. 110 volt D.C. motor using Model T Ford Generator

CHAPTER IV

Electric Welding 27

1. Theory
2. Making the Perfect Weld
3. Welding Generator using North East Type G or GA Generator
4. Welding Transformer

CHAPTER V

Page

Automobile Armatures 41

1. Winding
2. Reconnecting

CHAPTER VI

Wind Power Plan Head Mounting 47

CHAPTER VII

Water Wheel Drives 52

CHAPTER VIII

Miscellaneous 57

1. **Soldering Transformer**
2. **Growler**
3. **Magnetizer for Magneto Magnets**
4. **Gases from Water**
5. **Test Board**
6. **Noise Filters**
7. **Wire Table**
8. **Questions and Answers**
9. **Definitions**

CHAPTER I

General

STRIPPING OF THE ARMATURE IN PREPARATION FOR REWINDING

REMOVE the pulley from the shaft of the generator and take off both end plates. The armature may then be slipped out of the generator quite readily. The field coils are to be left intact in the housing provided they are in good condition.

The armature should be placed in a vise and the winding leads cut with a hack saw or diagonal cutters as close to the commutator as possible. Next drive the wedges from the slots with a dull narrow tool, being careful not to damage the fibre end laminations on each end of the steel laminations. After all of the wedges have been removed, turn the armature until you see the last coil that was wound on the armature. Remove this coil by pulling the wires out of the slots. Then remove the next top coil and continue this procedure until all of the coils have been removed from the armature.

There will now remain paper insulation and varnish in the slots and it is very important that all old materials be cleared from all slots so that all of the slot space will be available for the new insulation and winding.

Next cut two pieces of friction tape ¼" wide and apply them around the metal shoulders that hold the laminations together.

The slots are to be insulated with .007" or .010 insulating paper cut to the width of the laminations including the fibre end laminations. Before cutting the paper be sure that the grain of the paper runs across the width of the strip and not lengthwise. The grain of the paper may be determined by creasing the paper. It will crease readily in the direction of the grain of the paper while the crease across the grain will be rather jagged. The strip should be as long as possible since it will be used to insulate all of the armature slots. Make three wood pegs that have the shape of the slots and are about an inch longer than the slot. Now fold the strip of insulating paper into any slot and insert the peg to shape the paper and hold it in place. Then fold the paper into the adjacent slot and insert a peg to shape and hold it in place. Proceed in a like manner to insulate all of the remaining slots by removing the pegs from slots previously shaped. The armature is now ready to be wound.

CHAPTER I

General

STRIPPING OF THE ARMATURE IN PREPARATION FOR REWINDING

REMOVE the pulley from the shaft of the generator and take off both end plates. The armature may then be slipped out of the generator quite readily. The field coils are to be left intact in the housing provided they are in good condition.

The armature should be placed in a vise and the winding leads cut with a hack saw or diagonal cutters as close to the commutator as possible. Next drive the wedges from the slots with a dull narrow tool, being careful not to damage the fibre end laminations on each end of the steel laminations. After all of the wedges have been removed, turn the armature until you see the last coil that was wound on the armature. Remove this coil by pulling the wires out of the slots. Then remove the next top coil and continue this procedure until all of the coils have been removed from the armature.

There will now remain paper insulation and varnish in the slots and it is very important that all old materials be cleared from all slots so that all of the slot space will be available for the new insulation and winding.

Next cut two pieces of friction tape ¼" wide and apply them around the metal shoulders that hold the laminations together.

The slots are to be insulated with .007" or .010 insulating paper cut to the width of the laminations including the fibre end laminations. Before cutting the paper be sure that the grain of the paper runs across the width of the strip and not lengthwise. The grain of the paper may be determined by creasing the paper. It will crease readily in the direction of the grain of the paper while the crease across the grain will be rather jagged. The strip should be as long as possible since it will be used to insulate all of the armature slots. Make three wood pegs that have the shape of the slots and are about an inch longer than the slot. Now fold the strip of insulating paper into any slot and insert the peg to shape the paper and hold it in place. Then fold the paper into the adjacent slot and insert a peg to shape and hold it in place. Proceed in a like manner to insulate all of the remaining slots by removing the pegs from slots previously shaped. The armature is now ready to be wound.

CHAPTER I

General

STRIPPING OF THE ARMATURE IN PREPARATION FOR REWINDING

REMOVE the pulley from the shaft of the generator and take off both end plates. The armature may then be slipped out of the generator quite readily. The field coils are to be left intact in the housing provided they are in good condition.

The armature should be placed in a vise and the winding leads cut with a hack saw or diagonal cutters as close to the commutator as possible. Next drive the wedges from the slots with a dull narrow tool, being careful not to damage the fibre end laminations on each end of the steel laminations. After all of the wedges have been removed, turn the armature until you see the last coil that was wound on the armature. Remove this coil by pulling the wires out of the slots. Then remove the next top coil and continue this procedure until all of the coils have been removed from the armature.

There will now remain paper insulation and varnish in the slots and it is very important that all old materials be cleared from all slots so that all of the slot space will be available for the new insulation and winding.

Next cut two pieces of friction tape ¼" wide and apply them around the metal shoulders that hold the laminations together.

The slots are to be insulated with .007" or .010 insulating paper cut to the width of the laminations including the fibre end laminations. Before cutting the paper be sure that the grain of the paper runs across the width of the strip and not lengthwise. The grain of the paper may be determined by creasing the paper. It will crease readily in the direction of the grain of the paper while the crease across the grain will be rather jagged. The strip should be as long as possible since it will be used to insulate all of the armature slots. Make three wood pegs that have the shape of the slots and are about an inch longer than the slot. Now fold the strip of insulating paper into any slot and insert the peg to shape the paper and hold it in place. Then fold the paper into the adjacent slot and insert a peg to shape and hold it in place. Proceed in a like manner to insulate all of the remaining slots by removing the pegs from slots previously shaped. The armature is now ready to be wound.

Alternating Current Generators — 110 Volt 60 Cycle

¶ 1—100 WATT CONTINUOUS DUTY OR 200 WATT SHORT TIME DUTY A. C. GENERATOR USING MODEL T FORD GENERATOR 110 VOLT 60 CYCLE 1800 RPM

THE Model T Armature has 21 slots and it is recommended that each slot be numbered so that the schematic drawing shown below may be easily followed when winding the armature.

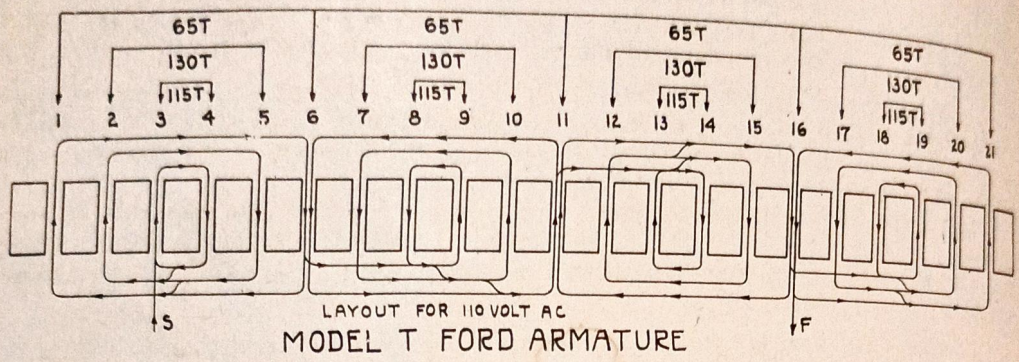


FIG. 1.

Using No. 25 Heavy Formvar Magnet Wire wind 115 turns in slots 3 and 4. From slot 4 move to slots 2 and 5 and wind in 130 turns. From slot 5 move to slots 1 and 6 and wind in 65 turns. This completes one pole winding of the armature.

In order to obtain opposite polarity in the adjacent pole the windings of that pole group must be wound in the opposite direction. From slot 6 move to slots 9 and 8 and wind in 115 turns in the opposite direction as shown in the schematic sketch above. From slot 8 move to slots 10 and 7 and wind 130 turns in the same direction. From Slot 7 move to slots 11 and 6 and wind 65 turns in the same direction. This completes the second pole group.

The third pole group is wound in the same direction as the first pole group. From slot 11 move to slots 14 and 13 and wind in 115 turns. From slot 13 move to slots 15 and 12 and wind in 130 turns. From slot 12 move to slots 16 and 11 and wind in 65 turns. This completes the third pole group.

The fourth and final pole group is wound in the same direction as the second pole group. From slot 16 move to slots 19 and 18 and wind in 115 turns. From slot 18 move to slots 20 and 17 and wind in 130 turns. From slot 17 move to slots 21 and 16 and wind in 65 turns. This completes the fourth pole group and the winding of the armature. Since the windings are all in series you will have the beginning of the winding from slot 3 and the end of the winding from slot 16.

Next cut the slot paper flush with the top of the laminations and bend the paper over into the slots so as to cover the wire. Put the wedges into the slots having previously cut the wedges for slots 3, 4, 8, 9, 13, 14, 18 and 19 slightly longer than the others so that the ends hold the short coils down. Fill slots 21 and 1 with wedges to take up the space left in them.

The polarity of the pole groups may be checked by passing a D.C. current through the winding. A compass should indicate opposite polarity over each adjacent pole group.

The commutator will be used as a slip ring or sliding contact to conduct the 110 volt current from the armature winding. Test the commutator bars for grounds to the shaft. The commutator surface should be smooth and polished, if ridged

or out of round it should be placed in a lathe and turned. Next clean the end of the bars where the windings were previously soldered and wind a piece of bare copper wire around the commutator and solder the wire to all of the bars so that the bars are all short circuited together.

The armature winding should now be tested for grounds to the core and if found okay one end should be grounded by soldering or brazing the wire to the shaft. The other end of the winding should be soldered to the wire short circuiting the commutator.

The armature is now completed and the generator is ready to be reassembled.

The field coils may be left connected in series in which case the generator may be connected to 100 watts load continuously or the field coils may be connected in parallel to give 200 watts output for 1 to 2 hours service.

¶ II—100 WATTS CONTINUOUS DUTY or 200 WATTS SHORT TIME DUTY A. C. GENERATOR USING THE FORD POWER HOUSE GENERATOR 110 VOLTS 60 CYCLE 1200 RPM

Before attempting to disassemble the generator it is suggested that Chapter One be read so that the proper procedure is followed in stripping the armature in preparation for rewinding.

The Ford Power House generator is a 6 pole generator and as a result should be driven at 1200 RPM to give a 60 cycle current.

To rewind the armature number the slots from 1 through 20 as shown in the schematic drawing below.

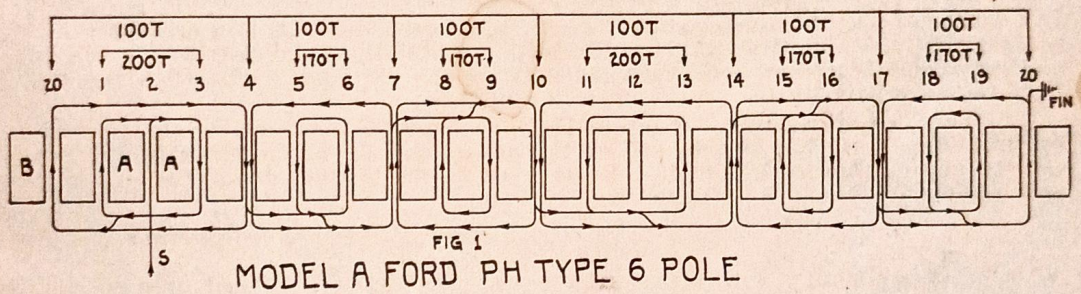


FIG 1

MODEL A FORD PH TYPE 6 POLE

Using No. 25 Heavy Formvar Magnet Wire wind 200 turns in slots 1 and 3. From slot 3 move to slots 20 and 4 and wind in 100 turns. Both coils must be wound in the same direction. This completes one pole group of the armature. In order to obtain opposite polarity in the next or adjacent pole the windings of that pole must be wound in the opposite direction. From slot 4 move to slots 6 and 5 and wind in 170 turns. From slot 5 move to slots 7 and 4 and wind in 100 turns. This completes the second pole group. From slot 7 carry the wire to slots 9 and 8 and wind in 170 turns in the same direction as the coils of pole group No. 1. From slot 8 move to slots 10 and 7 and wind in 100 turns. This completes pole group No. 3.

From slot 10 move to slots 13 and 11 and wind in 200 turns in the opposite direction from the preceding pole group. From slot 11 move to slots 14 and 10 and wind in 100 turns. This completes the fourth pole group.

From slot 14 proceed to slots 16 and 15 and wind in 170 turns in the opposite direction from pole group No. 4. From slot 15 move to slots 17 and 14 and wind in 100 turns completing pole group No. 5.

From slot 17 move to slots 19 and 18 and wind in 170 turns in the opposite direction from the preceding pole group. From slot 18 move to slots 20 and 17 and wind in 100 turns. This completes Pole Group No. 6 and the winding of the armature.

Cut the slot paper flush with the top of the laminations and bend the paper over into the slots so as to cover the wire. Insert the maple wedges over the paper so that the coils are held firmly in the slot. Check the winding for grounds to the core by using a test lamp as shown in Figure 3.

The polarity of each pole group may be checked by passing a D. C. current through the winding. A compass should indicate opposite polarity over each adjacent pole group.

Ground the start of the winding by soldering or brazing it to one of the bolts that hold the laminations together.

Clean all of the risers on the Commutator and test each bar for grounds to the core. If all of the bars are clear from grounds wrap a piece of copper wire around the risers and solder each bar to the wire. Then slip a piece of varnished tubing over the finish lead leaving the lead long enough so that it can be tied to the shaft and soldered to the wire around the commutator bars. Also tie the coils together with armature twine as shown in Figure 2. This will eliminate any possible breakage of the coils from vibration or centrifugal force. After testing for grounds, dip the armature in an air drying varnish and allow the armature to dry for several hours. The armature is now completed.

The voltage and amperage of the generator depends on the field excitation. The field coils may be connected in series or in groups as shown below in Figure 2.

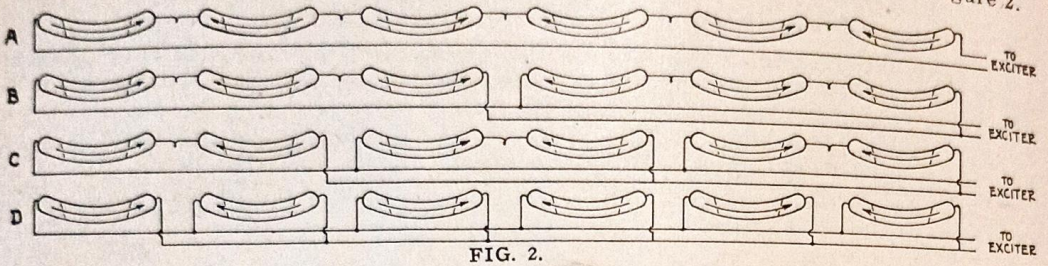


FIG. 2.

The output will increase as the number of coils in series is decreased. After determining the best grouping for the load, connect the field coils across the battery or D. C. Generator and check the polarity of each pole. Adjacent poles must have opposite polarity for proper operation of the generator.

Then reassemble the generator and connect the load across the generator by grounding one side of the load to the generator case and connecting the other side to one of the brush-holders. Remove all of the brushes except the one in the brush-holder to which the connection is made.

The output voltage is adjusted by placing a rheostat in the field coil circuit.

¶ III—300 WATT 110 VOLT 60 CYCLE 1800 RPM A. C. GENERATOR USING DELCO STARTER GENERATOR WITH ORIGINAL GENERATOR WINDING FOR SELF EXCITATION

Since the original generator winding will be used, extreme care must be exercised in removing the starter winding from the armature slots so that the generator winding is not damaged. Strip the starter winding as outlined in Chapter I. Then clean the shaft at the starter end with the edge of a file or sandpaper and wrap a piece of No. 16 bare copper wire twice around the shaft and twist the ends together so that they will hold to the shaft securely. Bring one end of this wire out between the generator winding and the starter commutator.

To wind the A. C. winding number the slots from 1 through 20 as shown in the schematic drawing below.

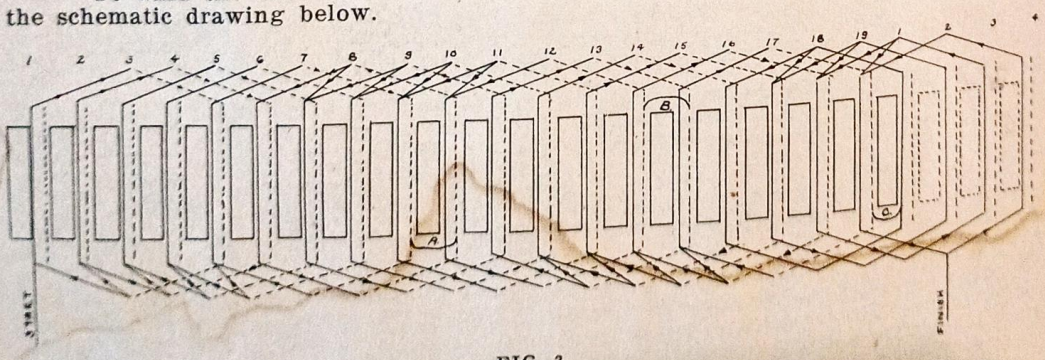


FIG. 3.

Cut 19 pieces of insulating paper 3¼" long by 2" wide and put a piece in each of the 20 slots. Wind 20 turns of No. 20 Heavy Formvar wire starting at the starter commutator end of slot 1 in slots 1 and 5. From slot 5 move to slots 2 and 6 and wind in 20 turns in the same direction. From slot 6 move to slots 3 and 7 and wind in 20 turns in the same direction. From slot 7 move to slots 4 and 8 and wind in 20 turns in the same direction. From slot 8 move to slots 5 and 9 and wind in 20 turns in the same direction. These first five coils constitute pole group No. 1. The windings should be put in firmly and tapped lightly to shape them. Bear in mind that you are working on the top of an old winding and that any pounding may short circuit or damage the generator winding.

From slot 9 move to slots 10 and 6 and wind in 20 turns in the opposite direction from the coils of pole group No. 1 so that this pole group will be of opposite polarity. See A, Figure 2. From slot 10 move to slots 7 and 11 and wind in 20 turns in the same direction. From slot 11 move to slots 8 and 12 and wind in 20 turns in the same direction. From slot 12 move to slots 9 and 13 and wind in 20 turns in the same direction. From slot 13 move to slots 10 and 14 and wind in 20 turns in the same direction. This completes pole group No. 2.

From slot 14 move to slots 15 and 11 as shown by B Figure 2 and wind in 20 turns in the opposite direction from that of pole group No. 2. From slot 15 move to slots 12 and 16 and wind in 20 turns in the same direction. From slot 16 move to slots 13 and 17 and wind in 20 turns in the same direction. From slot 17 move to slots 14 and 18 and wind in 20 turns in the same direction. From slot 18 move to slots 15 and 19 and wind in 20 turns in the same direction. This completes pole group No. 3.

From slot 19 move to slots 1 and 16 as shown by C, Figure 2 and wind in 20 turns in the opposite direction from the coils in pole group No. 3. From slot 1 move to slots 17 and 2 and wind in 20 turns in the same direction. From slot 2 move to slots 18 and 3 and wind in 20 turns in the same direction. From slot 3 move to slots 19 and 4 and wind in 20 turns in the same direction. This completes pole group No. 4.

The A. C. winding is now completed and consists of four pole groups of 5, 5, 5, and 4 coils each respectively.

The start of the winding should be soldered to the No. 16 wire which was fastened to the shaft. This connection should be tight and tied to the shaft so that it will not be thrown out by centrifugal force.

The finish of the winding should be soldered to one of the bars of the starter commutator and all of the bars of the starter commutator short circuited together by soldering a No. 16 bare copper wire to all of the bars on top of the risers.

Remove all of the original brushes from the starter brush holders and using a main Model T brush cut it to fit one of the brush holders in the starter brush rigging. The A. C. current will be drawn from this brush and the frame of the generator. Mount a brass strip on the generator end of the machine so it will contact the shaft, thus eliminating the current from going through the bearings.

¶ IV—500 WATT 110 VOLT 60 CYCLE 1800 RPM A. C. GENERATOR USING DELCO STARTER GENERATOR WITH NEW D. C. WINDING FOR SELF EXCITATION

Strip the armature completely as outlined in Chapter I and insulate the slots with .010 paper.

The D. C. winding consists of 5 turns of No. 20 Heavy Formvar wire and since this is a 19 slot armature and 38 bar commutator, it will necessitate one coil of one turn. To start the winding put this one turn coil in Bar 1 and slot 1 and make the wire just long enough to go through slots 1 and 6 and connect to Bar 20, but do not leave it in slot 6 until after the first 5 turn coil is wound. Start the 5 turn coil at Bars 2 and 3 with two wires in hand and wind 5 turns in slots 1 and 6. Then bring the end of the one turn coil into slot 6. Coil the ends of the wires so that they will be out of the way and continue the winding until it is necessary to put a winding on top of the bottom coil. Then remove the ends of the bottom coil from the slot until the turns of the top coil have been put into it. Then replace the ends of the coil in the slot and continue this procedure throughout the D. C. winding. The end of the one turn coil connected to Bar 1 is connected to Bar 20, the end of

the 5 turn coil connected to Bar 2 is connected to Bar 21 and so forth for the entire winding. After all wires have been connected to the commutator they should be soldered carefully.

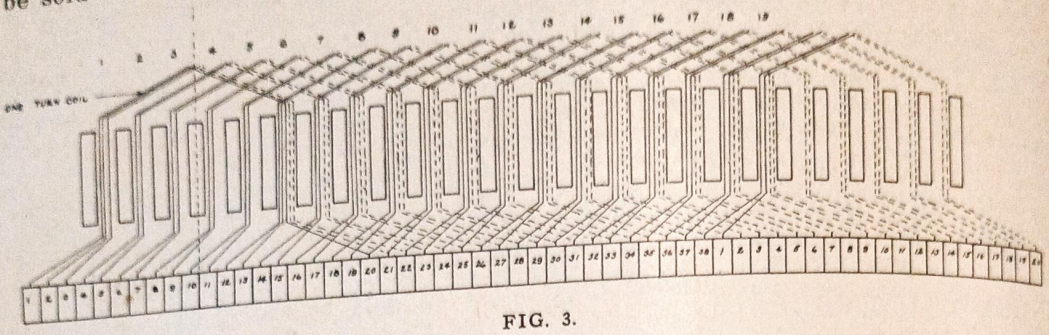


FIG. 3.

The A. C. winding is wound with No. 17 Heavy Formvar wire using 22 turns per coil. The same procedure as outlined for the 300 watt generator of Article III is to be followed.

¶ V—500 WATT SELF EXCITED 110 VOLT 60 CYCLE 1800 RPM A. C. GENERATOR USING DODGE TYPE G OR GA 12 VOLT D. C. GENERATOR

Strip the armature completely as outlined in Chapter I and insulate the slots with .010 insulating paper. Saw slots in the commutator risers to fit No. 20 bare copper wire.

Exciter Winding

Starting at any slot mark it No. 1 with chalk and number the remaining slots consecutively through No. 25 as shown in Figure 1 below.

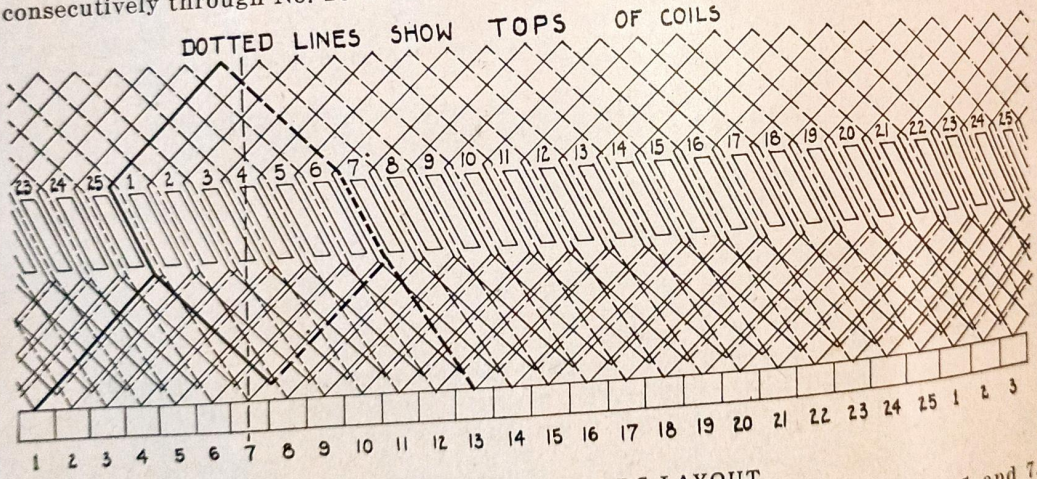


FIG. 1. DODGE 12 VOLT DC LAYOUT

Draw an imaginary line through the middle of a coil wound in slots 1 and 7. This line should hit Bar No. 7 (See Figure 1). Count to the left 7 bars and mark this Bar No. 1.

Using No. 20 Heavy Formvar wire remove the Heavy Formvar insulation about ¼" from the end of the wire and push a piece of cotton sleeving on the wire long enough so that the wire will extend from Bar 1 down to the shaft and then up to the armature slot. These sleeves are to be put on all leads to the commutator from both top and bottom windings. Then wedge the end of the wire in the slot cut in Bar 1 and leaving slack enough to extend the wire down to the shaft wind 3 turns in slots 1 and 7. Coming out of slot 7 cut the wire long enough to extend to the shaft and then up to Bar 13. Then follow the same procedure and wind a 3 turn coil in slots 2 and 8 wedging the start in Bar 2. As these coils are finished

take the finish lead and coil it so that it will be out of the way. Also when winding these coils leave enough slack in them so that they may be pushed easily below the vacant slots. Now move to Bar 3 and wind a 3 turn coil in slots 3 and 9. Follow this same procedure through to slot 7. Before winding the coil in slot 6 straighten the coils in the slots and tamp them down as far as possible.

Before winding the coil for Bar 7, take the last half turn of coil 1 out of slot 7 and leave it out until after coil 7 has been wound in slots 7 and 13. This coil will be on top of the first coil that was wound on the armature. Now replace the finish of coil 1 in slot 7. Follow this same procedure around the remainder of the armature slots. When the winding has been completed give it a bar to bar test for short circuits and grounds. Then put a layer of tape over the start leads of all coils to the commutator so as to secure them to the shaft. Now take any finish coil lead and after having cleaned the insulation from the end of the wire, attach it to one side of a Test Lamp. Move the other lead of the Test Lamp to the left across the commutator bars until the lamp lights. Mark this bar and count 13 bars to the right and connect the finish lead to that bar. Recheck with the lamp and recount the bars to be sure no error has been made.

Then take the finish lead that is in the adjacent slot to the right and connect it to the adjacent bar to the right. Continue this procedure until all of the finish leads have been connected to the commutator bars. Test for grounds and inspect the job thoroughly to be sure that all leads are in their proper slots before soldering the commutator risers.

A. C. Winding

Cut 25 strips of .010 insulating paper the width of the slots and long enough to lap over the D. C. winding. Place the strips over the D. C. winding and tamp the coils and strips firmly.

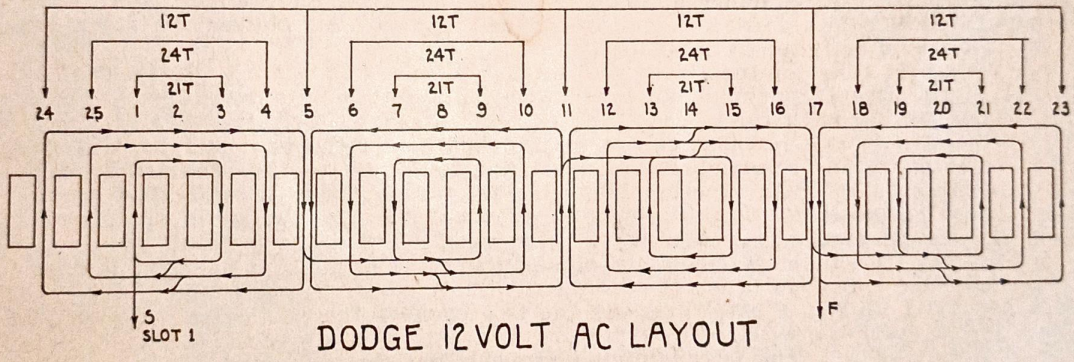


FIG. 2.

Using No. 16 Heavy Formvar wire wind 21 turns in slots 1 and 3, as shown in Figure 2, starting the winding from the pulley end of the armature. From slot 3 move to slots 25 and 4 and wind 24 turns in the same direction as the first coil. From Slot 4 move to slots 24 and 5 and wind 12 turns in the same direction. This completes pole group No. 1.

From slot 5 move to slots 9 and 7 and wind 21 turns in the opposite direction from the coils of pole group No. 1. From slot 7 move to slots 10 and 6 and wind 24 turns in the same direction. From slot 6 move to slot 11 and 5 and wind 12 turns in the same direction. This completes pole group No. 2.

From slot 11 move to slots 15 and 13 and wind 21 turns in the opposite direction from the coils of pole group No. 2. From slot 13 move to slots 16 and 12 and wind 24 turns in the same direction. From slot 12 move to slots 17 and 11 and wind 12 turns in the same direction. This completes pole group No. 3.

From slot 17 move to slots 21 and 19 and wind 21 turns in the opposite direction from the coils of pole group No. 3. From slot 19 move to slots 22 and 18 and wind 24 turns in the same direction. From slot 18 move to slots 23 and 17 and wind 12 turns in the same direction. This completes pole group No. 4 and the A. C. winding. Make the usual test for grounds.

Solder or braze the start of the winding to the bushing that slips on the shaft to hold the collector ring in place. The finish lead is soldered to the collector ring

as shown in Figure 3 below.

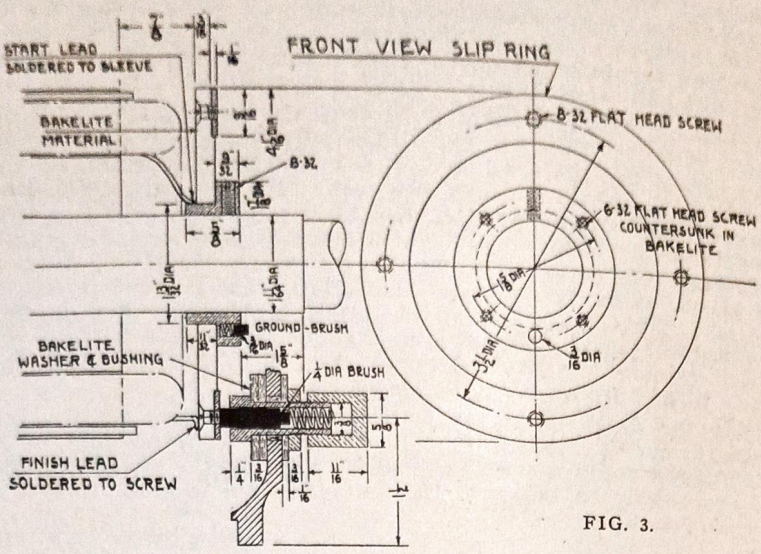


FIG. 3.

Figure 3 is a drawing of the cutaway and front view of the collector ring with its connections and also a cutaway of the 110 volt A. C. terminals. The ground brush wipes the inside cover of the bearing housing, giving a low resistance circuit for the ground side of the 110 volt A. C. line and eliminate static or capacity effect in the generator. The ¼" round brush shown contacting the plate at the screw where the finish lead is soldered conducts the current from the outside ring to the terminal. It is held against the ring by a small spring. All dimensions given are exact and should be followed implicitly.

The field coils for the Dodge 500 watt A. C. are wound with 1¼ lb. each of No. 17 S.C.E. wire (5 pounds) and taped with plain cotton tape over-lapped. (Use 1¼ lb. No. 17 for each coil.)

Using only two brushes, the regulating brush and the one next to it at the right (looking at the commutator), connect one field lead to the regulating brush and the other to the other brush. Move the regulating brush over as close to the other brush as possible. Start the generator up and increase the speed up to about 1200 R.P.M. It should be generating at this speed. Put a short circuit across the two brushes. It should immediately commence to generate. If it does not, reverse the leads from one brush to the other. Short circuit it again and if the field does not build up put a battery across the two brushes for an instant. (Also see Chap. II for other causes.)

When the D.C. end is functioning properly put the A.C. load (500 watt) on and bring the generator up to full speed 1800 R.P.M. Then regulate voltage with regulating brush. It is 60 cycles, 110 volt, 500 watt capacity at this speed.

If this job is made separately excited, use the commutator for a collector ring and shaft for ground. Wind the armature for A.C. only with same number of turns but use No. 15 S.C.E. wire.

Wind the fields the same 225 turns with No. 17 S.C.E. Leave them all in series if exciting with an auto generator, but parallel them in two groups of two each if using a battery for exciter.

This job is good for 110 volts, 700 watts, wound with No. 15 wire and separately excited, 60 cycle at 1800 R.P.M.

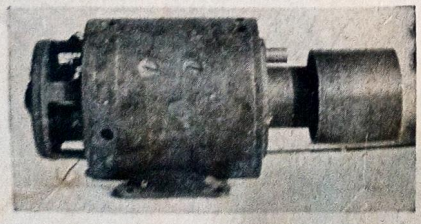


FIG. 4.

Fig. 4 shows the completed Dodge generator from 12 volt to 110 volt 500 watt self-excited. Notice the terminal that is mounted in the end-housing; it is above the bearing housing on the pulley end of the generator.

The old type tapered bearings that were originally in this job can be taken up by pushing the outer race in toward the armature but if the races are pitted, new bearings are advisable.

The base shown in the cut of completed Dodge generator is a base from a General Electric fractional horsepower motor.

Boring holes through the pulley end of the generator housing will help to keep them cool and add to the efficiency of the machines.

(Figure 5 shows front view of Dodge armature. Notice how the D. C. winding is laid under the A.C. and how the A.C. is connected to the collector ring.)

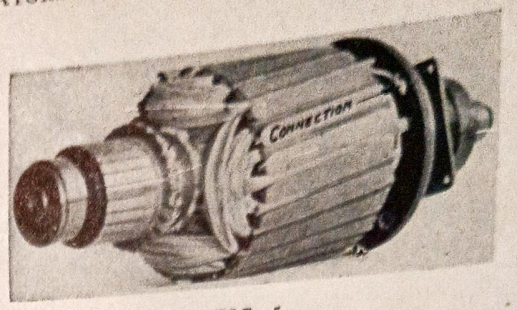


FIG. 5.

Use the sealed ball bearings whenever possible with the sealed side next to the winding except on the pulley end of the Dodge 12-volt generator. (See figure 6.) Put the sealed side out to keep dust and grit from getting into the bearing.

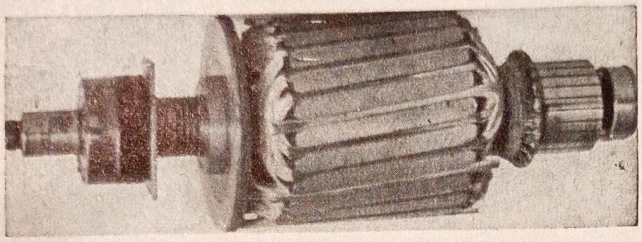


FIG. 6.

The sealed bearing is the regular ball bearing with a metal plate made fast to the outside ball race.

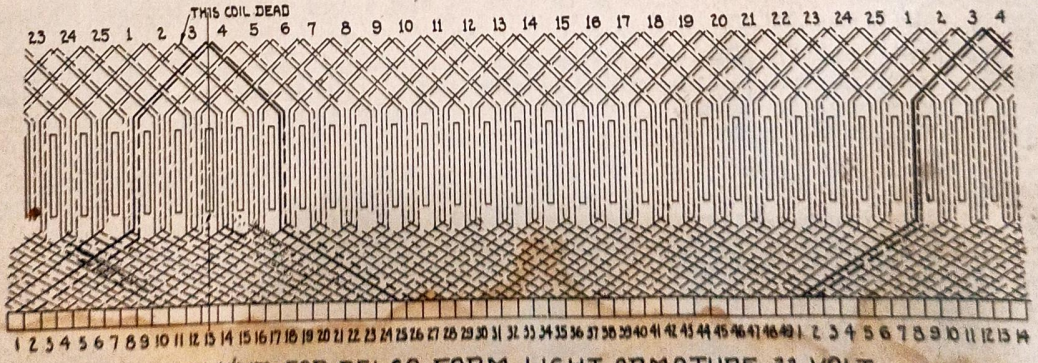
If it is practical the armature and field coils should be dipped in the varnish and baked or let air dry. If baked they should be put in the oven of about 250 degrees Fahrenheit for about four hours, dipped in the varnish until all the bubbles disappear, let drain and replace in the oven for six to eight hours. If air drying varnish is used place the armature in a warm dry place for at least 24 hours. While the air drying varnish dries in one to two hours, it does not work this way on armatures, as the outside varnish dries in an hour or two, but the inside varnish does not, and the result when the armature is put into the machine is the varnish is thrown out by centrifugal force. Use white high test gasoline for thinner.

¶ VI—500 WATT USING DELCO 500 WATT 32 VOLT FARM LIGHT PLANT SELF EXCITED DRIVEN 1800 RPM

Strip the armature as outlined in Chapter I.

Before the armature is rewound, remove two of the screws that hold the commutator together and put two No. 16 rubber covered wires through these holes. The screws removed should be diametrically opposite so as to separate the leads as much as possible.

The D.C. exciter winding will be wound with No. 23 Heavy Formvar and No. 23 Single Cotton Enamel Magnet Wire. The coils are to be wound two in hand of No. 23 Heavy Formvar and No. 23 Single Cotton Enamel, 8 turns of each size wire per coil. The span of each coil will be slots 1 and 6. The armature layout for the D.C. exciter winding is shown below.



D.C. LAYOUT FOR DELCO FARM LIGHT ARMATURE 32 VOLT FIG. 1.

The commutator connections are 1 and 25 as indicated in Figure 1.

After the D.C. winding has been placed in the armature put strips of .010 insulating paper on top of the D.C. Winding and bind it down with cotton tape as shown in Figure 2B.

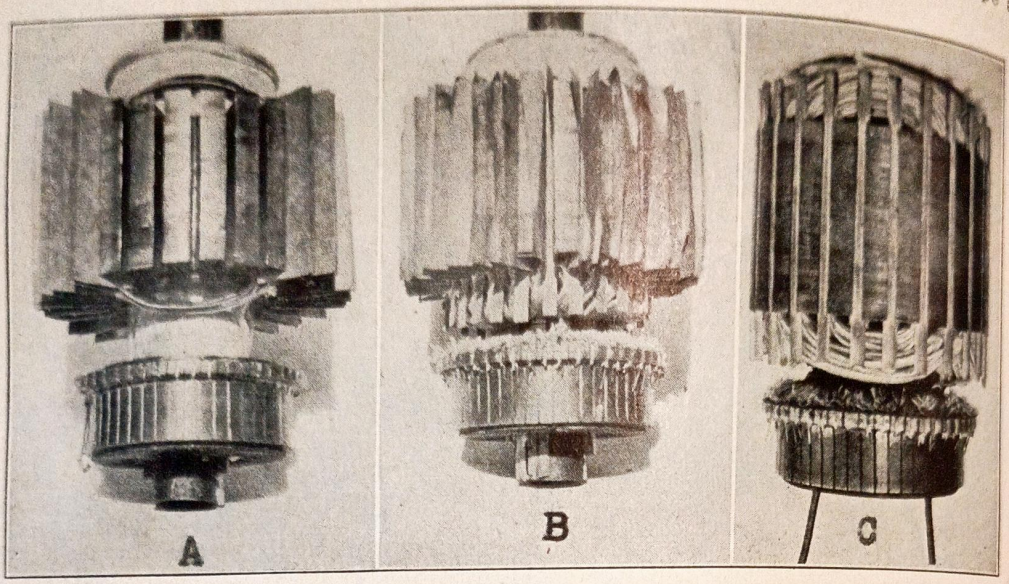
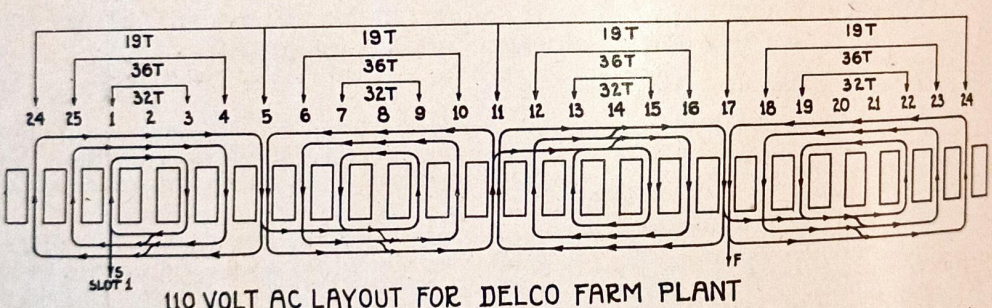


FIG. 2.

Using No. 17 Heavy Formvar Wire solder the start of the A.C. winding to one of the rubber covered wires that had previously been brought through the commutator. Insulate the connection with a short piece of varnished tubing. Then wind 32 turns in slots 1 and 3. From slot 3 move to slots 25 and 4 and wind 36 turns. From slot 4 move to slots 24 and 5 and wind 19 turns. This completes pole group No. 1.



110 VOLT AC LAYOUT FOR DELCO FARM PLANT

From slot 5 move to slots 9 and 7 and wind 32 turns in the opposite direction from the coils of pole group No. 1. From slot 7 move to slots 10 and 6 and wind 36 turns. From slot 6 move to slots 11 and 5 and wind 19 turns. This completes pole group No. 2.

From slot 11 move to slots 15 and 13 and wind 32 turns in the opposite direction from the coils of the previous pole group. From slot 13 move to slots 16 and 12 and wind 36 turns. From slot 12 move to slots 17 and 11 and wind 19 turns. This completes pole group No. 3.

From slot 17 move to slots 22 and 19 and wind 32 turns in the opposite direction from the coils of pole group No. 3. From slot 19 move to slots 23 and 18 and wind 36 turns. From slot 18 move to slots 34 and 17 and wind 19 turns. This completes pole group No. 4 and the A.C. winding. Connect the finish of the winding to the other rubber covered lead through the commutator. Be sure to insulate the connection with a piece of varnished tubing.

Two collector rings are to be made such as the ones shown in Figure 3, the outer ring is to be 4 inches in diameter and the inner ring 2½ inches in diameter. Both are mounted on a 3/16 inch thick phenol fibre piece with a 1/32 inch piece of fibre between the phenol fibre and the end of the commutator. The rubber cov-

ered wires through the commutator are connected, one to the outer ring the other to the inner ring. Brushes and brush-holders are mounted as shown in Figure 3. The A. C. load is connected across the slip ring brush-holders.

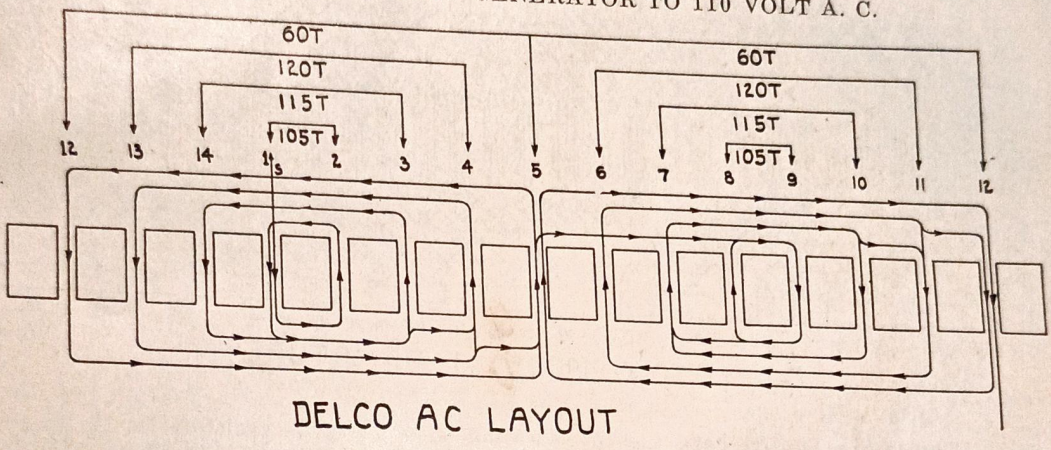
The field coils are left unchanged.

¶ VII—100 WATT USING DELCO REMY OR AUTO LITE 14 SLOT GENERATOR, SEPARATELY EXCITED, DRIVEN 3600 RPM

Strip the armature as outlined in Chapter I.

Using No. 23 Single Cotton Enamel Magnet Wire start the first coil from the pulley side of the armature and wind 105 turns in slots 1 and 2 as shown in Figure 1 below.

CHANGE DELCO-REMY GENERATOR TO 110 VOLT A. C.



DELCO AC LAYOUT

From slot 1 move to slots 3 and 14 and wind 115 turns. From slot 14 move to slots 4 and 13 and wind 120 turns. From slot 13 move to slots 5 and 12 and wind 60 turns. All of these coils are wound in the same direction. These coils complete pole group No. 1.

From slot 5 move to slots 9 and 8 and wind 105 turns in the opposite direction from the coils of pole group No. 1. All coils of pole group No. 2 are wound in this same direction. From slot 9 move to slots 7 and 10 and wind 115 turns. From slot 7 move to slots 11 and 6 and wind 120 turns. From slot 6 move to slots 12 and 5 and wind 60 turns. This completes pole group No. 2 and the winding of the armature since this is a two pole generator and must be run 3600 RPM to generate a 60 cycle current.

Test the winding for grounds and if found clear, solder the start of the winding to the shaft.

The commutator will be used as a slip ring to conduct the current from the winding. Test the commutator for grounds to the shaft. The commutator should be smooth and polished, if ridged or out of round it should be placed in a lathe and turned. Next clean the end of the bars where the windings were previously soldered and wind a piece of bare copper wire around the the commutator and solder the wire to all of the bars so that the bars are all short circuited together. The finish of the armature winding is soldered to the wire short circuiting the commutator.

Tamp the ends of the coils back toward the laminations on each end and tie the coils together with armature twine to prevent them from being thrown out by centrifugal force.

Since the speed is 3600 RPM it is suggested that the armature be dipped in No. 30 Red Protective Sealer to bind the coils together thoroughly.

CHAPTER II

Direct Current Generators

¶ Ia—32-VOLT DC 150 WATTS USING MODEL T GENERATOR

THE coil span of six slots and connections to commutator bars 1 and 11 are the same as for the original winding. It is advisable to trace out the top coil in the original winding and number the slots and commutator bars as shown in the DC layout shown below.

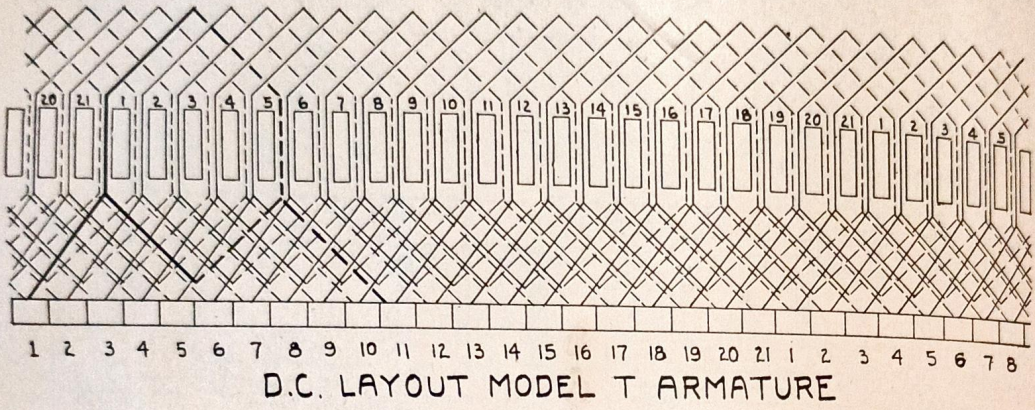


FIG. 1.

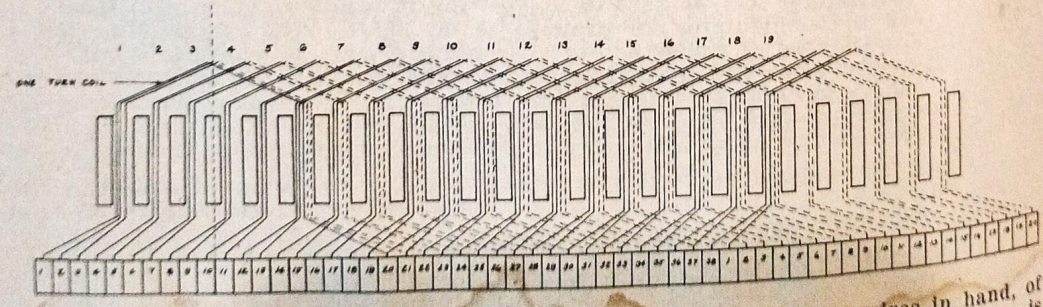
The new armature coils are to be wound with 20 turns each of No. 21 Single Cotton Enamel wire. The coils may be form wound or may be wound directly in the slots.

The new field coils are wound with ⅜ pound per coil of No. 26 Plain Enamel wire. One of the field coil leads is connected to the generator frame or the grounded brush-holder. The other field coil lead is connected to the small regulating brush holder.

The 32 volt output is taken from the generator frame and the large brush holder which is not grounded. The output is 150 watts at 1200 RPM.

¶ Ib—32-VOLT DC 300 WATTS USING DELCO STARTER GENERATOR

The coil span is 1 and 6 and commutator connections are 1 and 20 as shown in DC layout below.



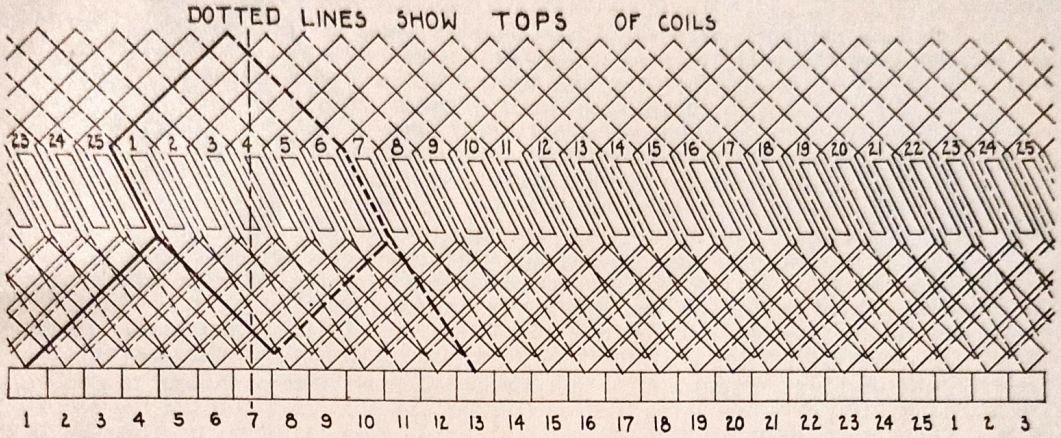
The armature coils are wound with 11 turns per coil, two wires in hand, of No. 17 S.C.E. wire. It will be noted in the DC layout that one coil of one turn is required. See the directions for the DC winding for the 500 watt AC Delco Starter Generator with new DC winding for the connections of the one turn coil.

The field coils are wound with 560 turns or one pound per coil of No. 22 P.E. wire.

The output is 10 amperes at 1400 RPM.

¶ Ic—32-VOLT DC 500 WATTS USING NORTH EAST TYPE G OR GA GENERATOR

The coil span is 1 and 7 and commutator connections are 1 and 13 as shown in the DC layout below.



The armature coils are wound with 11 turns per coil of No. 15 S.C.E. magnet wire.

The field coils are wound with 425 turns or 1¼ pound each of No. 20 Plain Enamel magnet wire and taped with two layers of cotton tape double lapped.

Connect the field leads and the load to the two stationary brushes.

The generator will develop 500 watts at 32 volts at speeds from 1200 to 1800 RPM.

¶ II—110-VOLT DC 500 WATTS USING NORTH EAST TYPE G OR GA GENERATOR

The coil span is 1 and 7 and the commutator connections are 1 and 25 using a 49 bar commutator as shown in the DC layout below.

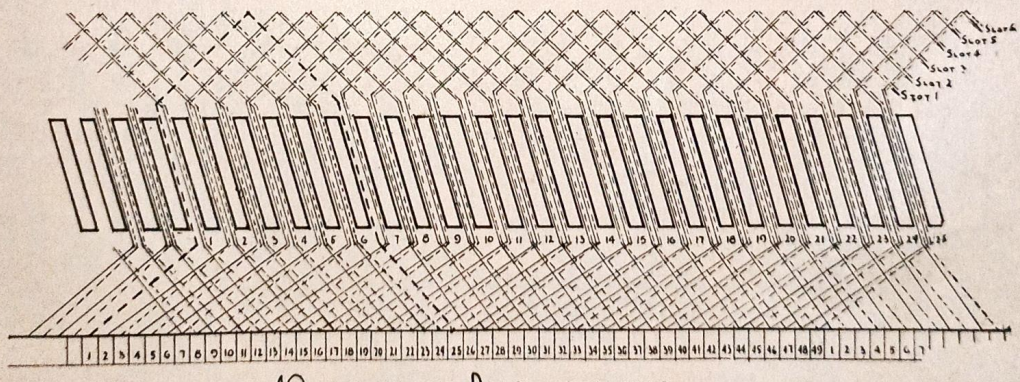


FIG. 10. 49 BAR LAYOUT FOR DODGE GENERATOR.

The armature coils are wound with 13 turns per coil, two wires in hand of No. 18 S.C.E. magnet wire.

The field coils are wound with 2100 turns or 1½ pounds per coil of No. 26 Plain Enamel wire.

The field coils and load are connected to the two stationary brushes.

¶ III—400-VOLT DC 100 WATTS USING FORD POWERHOUSE GENERATOR

This generator has been selected to supply plate voltage for radio tube operation as it has more segments in the commutator than any other popular automobile armature, and this would give less commutator ripple.

Strip the armature as has previously been outlined. Clean the laminations and the commutator thoroughly, scraping the mica clean at both ends of the commutator and between the bars, as a good commutator is very important in this machine.

Grind an ordinary hack saw blade on both sides of the teeth until the teeth are thinner than the other part of the blade. Break or grind the front end of the blade off on an angle sloping from the back down to the teeth. Use this tool to scrape the old carbon and charred mica out between the bars on top, in the front, and back of commutator. Be sure a good job is done on this but only scrape where the rings look black and undercut the mica between the bars about 1/64 of an inch.

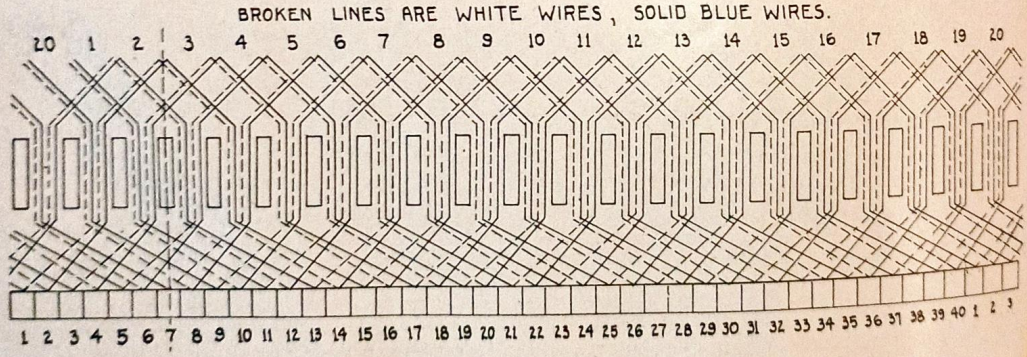
Test the commutator for ground by placing one lead of the test lamp on the armature frame and pass the other lead slowly around the commutator, being sure each bar is contacted by the lead being passed around it.

Should the test lamp light on any bar, this indicates a ground. Look carefully in the back and front of this bar for minute pieces of copper, solder or carbonized mica, remove same and make test again. If unable to find any foreign substance, the commutator is most likely beyond repair and due to the construction of Auto Generator Commutators the only thing to do would be to replace with a good one.

Assuming the commutator is not grounded, next test each bar to each adjacent bar, putting one test lamp lead on one bar and the other lead on the bar next to it. Then move right around the commutator in this manner until all the bars have been tested. Should a light show up in this test, look for small metallic particles between bars, in back, front and on top of the risers. Charred mica generally shows up by a red glow and smoking. This usually can be rectified by scraping the mica clean.

Cut a piece of insulating paper to fit from the neck of the armature just behind the commutator to the shoulders where the bolts come through that hold the laminations together. This paper should cover all the exposed parts between the laminations and the commutator. Shellac or glue this paper around the armature neck. Fill neck up with cotton tape to just below the bars or to the mica in the back. This will help hold the paper on, and act as a support for the DC winding.

This armature has 20 slots and 6 poles, to find the number of slots each coil will lie in, divide 20 by 6 equals 3 and ⅓ slots. As slots cannot be divided up, 3 or 4 slots have to be used, 3 is rather short, so the DC winding will span 4 slots or 3 armature teeth.

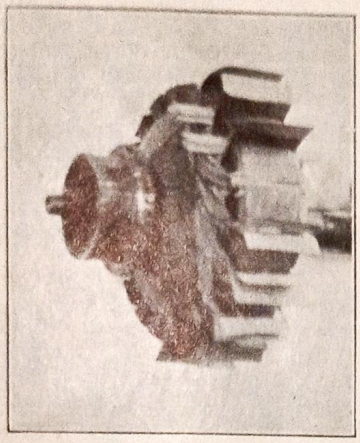


MODEL A FORD PH TYPE 6 POLE FIG. 6.

Upon counting the commutator bars it is disclosed that there are 40 bars. This indicates that there are two coils to the slot.

To find the commutator pitch divide the number of bars (40) by the number of PAIRS of poles (3). Forty divided by three equals 13 and ⅓, or 14 bars. To locate these bars on the commutator draw an imaginary line through the middle of

the slots, a coil is to lie as per Fig. 6. This line is also the middle of the commutator connections and should be between bar 7 and 8 or on one of these bars. Assuming it hits the mica between 7 and 8. Start on bar 7, count back to the left seven bars. This bar will be number one. Insulate the slots with one strip of .010 oil linen cloth and one strip of .007 slot paper. After insulating the slots, fill 2 adjacent slots with wedges or pegs, start the first coil spanning 1 and 4, and wind the coils so that the wedges in the 2 vacant slots will hold the coil down below the vacant slots. Wind each coil with 2 wires in hand (2 colors), with 150 turns of No. 33 S.S.E. wire. Two colors for example, white and blue. Clean the insulation for about ¾" on the white wire (do a good job, be sure the wire is bright all around) with 1½" of sleeving on each wire, place it in the slot in the riser of bar 1, with the insulation as close to the back of the riser as possible, yet keeping the clean wire in the riser slot. To hold this wire in place drive a piece of old wire the armature was wound with down on top of the 33. Be sure this wire is clean, or better, tinned. Follow the same procedure with the blue wire and put the blue wire in the riser of bar 2. Lay these wires down on the tape in the neck of the armature and form them against the support of the laminations, into slot 1, then back out though slot 4, connect the white one at bar 14 and the blue at bar 15 using sleeving to extend from slot to bar.



Notice how the wooden wedges are placed in the slots; to hold the coil being wound, down, below the bottom of the slots.

Start again with a white wire in bar 3, blue in bar 4. Lay wires in slots 2 and 5. These leads will terminate at bars, white at 16 and blue at 17. Carry this procedure through until the DC winding is completed. Solder and test as per Chapter II.

Leave the field coils connected as they originally were and excite them with 6 volts direct current. The 400 volts will come from the 2 large brushes. If higher voltage is desired, arrange the brush holders with 6 brushes and connect every other brush together, and drive the generator at a high speed or connect the fields in groups of 3 parallel.

¶ IV—1000-VOLT DC 500 WATTS USING NORTH EAST TYPE G OR GA GENERATOR

First strip the armature and field coils from their respective frames and insulate the armature for winding with one layer of .005 varnished cloth and one layer of .007 paper.

Wind the armature with 80 turns per coil, 2 in hand, of No. 28 single silk enamel covered wire, using two colors to help in keeping the commutator connections correct.

It is necessary to use a 49 bar commutator on this machine and to insulate the coils in the slots from each other by putting another piece of paper in the slot when the coils are to be wound on the top and the bottom of the coils and insulate each coil from the other on the ends by a piece of .005 varnished cloth.

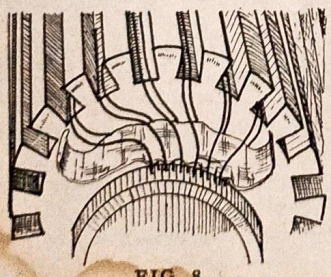


FIG. 8.

Where the ends of the coils connect to the commutator, use strips of varnished cloth woven in and out between the leads to separate each one from the other. If the finishes of the coils (the ends of the last turn) are left out, or not put down until all the coils are in, another wrapping of .005 varnished cloth should be laid on the armature between the bottom and top leads. The varnished cloth should be woven between the top layers to separate them.

When soldering this commutator, do not use anything but soldering paste. Tilt the armature on an angle so that the solder or paste will not run behind the commutator. Wash the commutator risers with alcohol to remove all traces of commutator paste and let it thoroughly dry before dipping and baking. Test the two stationary brushes in the end

housing to ground with 1500 volts or as high a voltage as possible after they have been cleaned with naphtha or gasoline and all carbonized pieces of insulation either scraped clean or replaced. The field coils are wound with 1½ pounds of No. 15 plain enamel wire, connected in series and the ends of the set of coils connected to a 6 volt battery for excitation.

The 1000 volts are taken from the two stationary brushes when the armature is driven at a speed of approximately 1500 RPM. When using it for plate voltage for a transmitter, a switch can be put in series with one side of the battery and the field coils, and the generator can be left running.

When it is desired to use it, throw the switch so that the fields will be excited. It would be advisable to put a small .1 mfd. 600 volt condenser across the

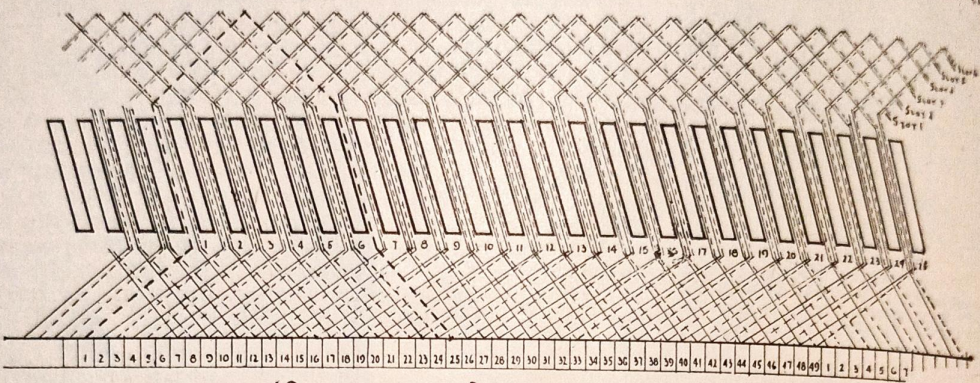


FIG. 10. 49 BAR LAYOUT FOR DODGE GENERATOR.

switch to take care of the voltage left in the fields when the switch is open. This generator should be painted red, and marked 1000 volts as it will develop approximately ½ ampere at 1000 volts.

NOTE: In Figure 10 of the 49 bar commutator, the first coil, which lies in slots 1 and 7 and connected to bars 1 and 25, is wound with only one wire. Put this coil in first to insure proper span and commutator connection.

¶ V—CHARACTERISTICS OF D. C. GENERATORS

There are many things that are common to all motors and generators, such as, fields, armatures, brushes, brush holders, frames, bearings, etc., and to have a clear understanding of how they function is very important when working on them.

The fields are magnets that send to and receive from each other lines of magnetism from the poles on both sides of each other. This magnetism or lines of force, are cut by the armature winding when it revolves, and the electricity is induced into the winding. The iron on the armature concentrates this magnetism so that the wire on the armature receives the full benefit of the magnetism.

The commutator is a device used to bring the current out to the brushes, and is connected to the armature winding so that when the current in a coil is of one polarity it will contact one brush and when of opposite polarity it will contact the next brush, thus producing D. C. current.

The brushes are made of carbon to reduce friction and are used to carry the current out to the line or receive current from the line, when used as a motor.

A generator works very similar to a cistern pump, the type that has a number of small buckets on an endless chain. The buckets go down in the water, dip it up, and at the proper time, pour it out at the spout.

So it is with the generator, the armature coils collect up the electricity and carry it to the commutator and pour it out through the brushes to the line.

The brush holders are usually movable so that they can be adjusted to the point where they will be most efficient.

Magnets are not only held in their proper places by the frame, but the frame also furnishes a return path for the magnetism.

Bearings are a very important part of a generator. They keep the armature in its proper place and maintain an even space between the pole faces and the arma-

ture. A great percentage of all generator and motor failures are due to poor or worn out bearings.

Many of the following undesirable conditions can be traced to worn bearings; noise, excessive sparking at brushes, poor or no voltage, due to armature dragging on poles.

Generators generally speaking, are of two classes, separate and self-excited. The separate excited generator has its field magnetized from some external source of direct current, a generator or battery. The self-excited generator produces its own excitation by building up the field from the permanent magnetism that resides in the pole pieces. This field increases in intensity as the speed of the armature increases. Some times a generator loses this permanent magnetism and it is necessary to connect a D. C. current across the field to get it magnetized again.

CAUSES FOR FAILURE OF D. C. GENERATORS

1. No voltage.

First make test at the generator itself. The trouble may be in the wiring going to the load. This may be done by putting a short circuit on the generator where the load was connected. Often times the residual magnetism becomes so weak that the field will not build up and when a short circuit is put on it for a second or so, it will build up immediately.

NEVER do this to a machine of over a 1000 Watt capacity as the flash is so great that it might result in an injury.

2. Wrong field connections at brushes. Reverse the field leads.

3. Disconnect field leads from brushes and test for an open circuit, and a ground.

4. Check brushes to see that they are contacting the commutator properly and are set in their proper position, and see that the mica beween the bars is lower than the copper.

5. Open, or grounded armature.

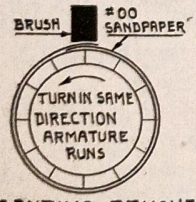
6. Poor bearings, allowing armature to strike the pole pieces.

CAUSES OF LOW VOLTAGE

Speed too low, belt slipping, weak field, may be caused by low voltage of exciter (if separately excited). Poor commutation caused by commutator out of round, high mica, rough commutator, brushes not seating properly, regulating brush not adjusted properly, one or more field coils have wrong polarity, poor connection between coils and at brushes, causing resistance, or a short circuited coil in the armature.

CAUSES OF EXCESSIVE SPARKING AT BRUSHES

1. Brushes out of commutating plane. (See neutralize armature.)



SANDING BRUSHES

2. Brushes not seating properly on commutator.

3. Poor bearings.

4. Wrong commutator connection.

5. Brushes covering too many bars or not enough.

6. Overloaded machine.

When turning a commutator in a lathe always check the centers of the shaft, at both ends, while in the lathe. For if the commutator is turned out of round in relation to the shaft it may work all right at low speeds and fail at high speed.

FORMULA FOR LOAD

To find the number of lamps any generator will carry divide the wattage of the generator by the watts of the bulbs you intend to use.

To determine the polarity of any D. C. line place the bare ends of both lines in a glass container of salt water solution keeping the ends as far apart as possible. After a few seconds in the solution minute bubbles will appear on the negative wire.

MAKING FIELD AND ARMATURE COILS

First make a form using two pieces of ⅜" to ½" thick, soft wood. Length and breadth depending on the size of coil that is to be made. Then on one side of one of the pieces find the exact center by either measuring for same, or by draw-

ing lines diagonally across the board from the upper left hand corner to the lower right hand corner and from the upper right hand corner to the lower left. Then mark on the same piece, the dimensions for the coil to be made. As the coils are to be wound in a lathe or breast drill held in a vise, the center hole should be made to take a threaded bolt that will be of convenient size for the drill chuck. Clamp both pieces together in a vise, keeping them even at the sides and ends, and bore four holes through them where they have been marked off for the coil to be made. Keep the drill hole just inside the line so that when the coil is finished the inside of the coil will conform to the dimension desired. (See Fig. 1 for a form set up to wind a coil.)

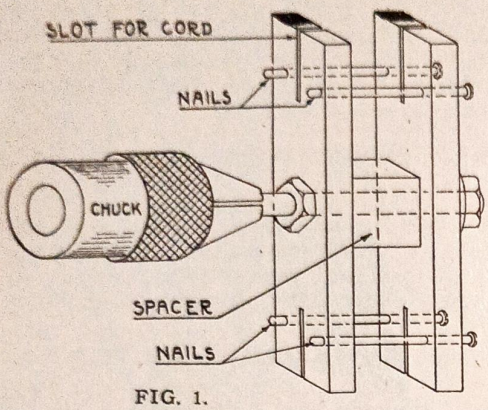


FIG. 1.

Drill these holes large enough for a snug fit for a nail that you think will be strong enough to do the job. (1/16 inch to ⅛ inch holes for auto coils.) Paraffin the nails and push them through the holes while still in the vise. Turn the boards up lengthwise and saw a slot through both of them in the center to about ¼" below the line where the nails are. Turn the boards over and saw a slot in the other end the same as the one just finished.

Paint one corner of both boards on the edges to help in counting turns and keeping the right sides together so that the holes for nails will match up.

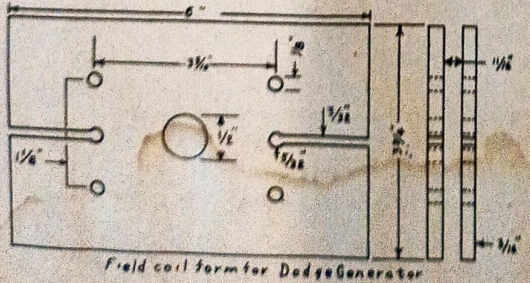
To assemble the form for winding, cut the bolt head off that is to be used in the center, and place it in the chuck of the drill, lathe, or whatever it is to be used in, with the thread side out. Run a nut as far as the threads go, then place one of the sides of the form on the bolt and push it up against the nut. Place a spacer on the bolt the desired width you intend to make the coils. (Use washers or a piece of hard wood or metal. Be sure that there is plenty of clearance between the spacer and the coil to be made.) Place the other side of the form on the bolt and push the nails through the holes bored for them. With a washer next to the outside form, tighten the two together with a nut until you are sure the form will not slip.

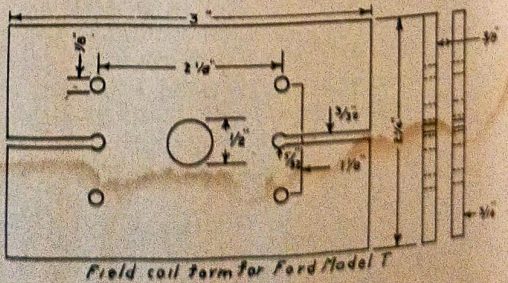
Pass a piece of cord down the slots that were sawed in the ends, and let them lie loose in the bottom of the slots and wrap each end around the nails. These are to tie the turns in the coils together before they are taken off the forms. This keeps the coil intact until it is taped or put in the armature.

Take the beginning of the wire to be used in winding the coil and pass it down the slot on the side that is painted. Turn the form slowly at first for a few turns, then increase the speed and tension on the wire as desired. When the desired number of turns have been made, TIE THE COILS with the cord on both ends of the coil. Cut the wire an inch or so longer than seems necessary for the lead.

Remove the nut and washer, and slip the form from the bolt. Pull the nails carefully from the form. Examine the inside of the coil in the corners to make sure the insulation has not been damaged by the nails.

Paraffin the nails each time a coil is made, and repeat the procedure for as many coils as desired. As everyone will not make the forms the same size weight is given instead of turns.


Field coil form for Dodge Generator


Field coil form for Ford Model T

TAPING FIELD COILS

When two or more field coils have been wound, lay them flat on a table or bench so that all the starts (the inside leads) will be visible and all of them come out on the same side of their respective coils. For example: assume there are four coils lying on the table, beginning at the left, there would be a finish, start, finish, start, finish, start, finish, start.

To connect them up for proper polarity: assume the first finish is going to be a field lead. They would be connected start to start, finish to finish, and start to start, or in other words, inside to inside, outside to outside, inside to inside. The other two outside leads would be long leads for brush rigging, etc. (Refer to Figure 2.)

Solder a piece of flexible wire to the finishes and insulate them well from the rest of the coil. Put a sleeve on the start of the first coil to protect the wires it will lay over. Start the tape at the corner of the outside lead, tape the coil past the connections, then lap back and tape the lead down to the coil and tape right on around the coil to the other lead. Bring this lead out at the opposite corner and finish the taping around the corner. The tape should lap half way over each previous turn.

For low voltage where cotton enamel wire is used, one taping if well lapped is sufficient; when using plain enamel, tape the coils twice, first with oiled linen and once with plain cotton tape.

When taping small coils use tape ½" wide, as it is much easier handled and makes a better looking job.

ALWAYS CHECK THE FIELDS FOR POLARITY BEFORE AND AFTER putting them in their frame.

FIELD CONNECTIONS

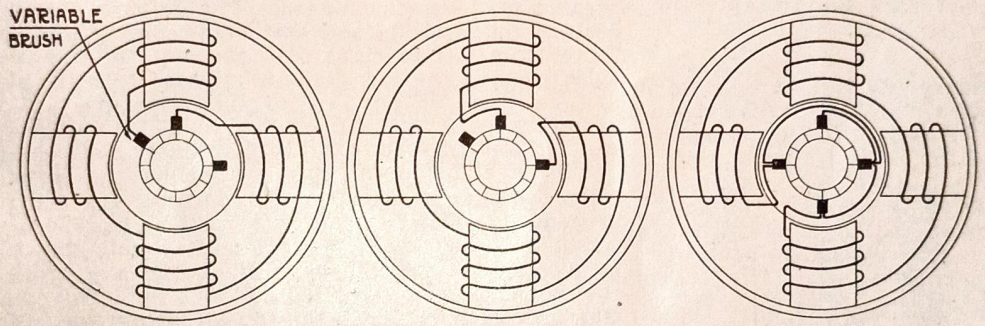
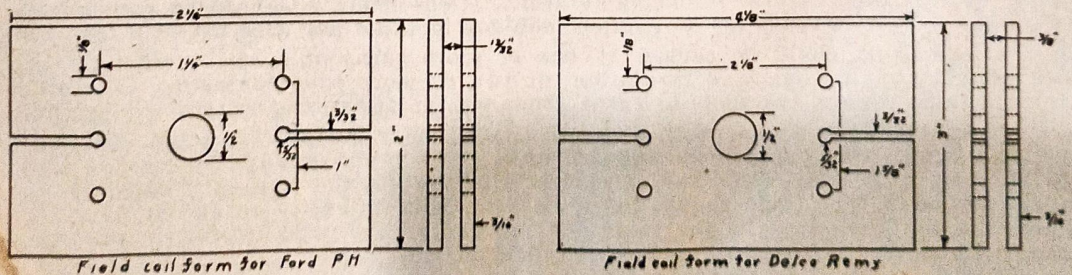


FIG. 2.



CAUSES FOR ARMATURE FAILURE

1. Short circuits: At commutator bars. From solder or other metal being between bars, wrong connections, or charred mica.

Short in one or more turns in a single coil due to poor or damaged insulation.

Short in two coils contacting each other from poor or damaged insulation.

2. Open circuit: Due to wires not being soldered in commutator risers properly, or having become unsoldered by heat from commutator or over-load.

3. Ground: Winding contacting iron laminations, or insulation broken down in commutator, or both.

To test an armature for ground, place one lead of a test lamp on the shaft or laminations, and the other on the commutator. If the lamp lights it indicates a ground. To determine which coil or coils is grounded, lift the top leads out of the commutator bars and test each bar separately for a ground. When the lamp lights, trace the lead to coil and examine the slots for broken down insulation, and see that the wedge is not holding a turn against the iron.

To test the coils for a short circuit, raise the top leads from the commutator (make this test when winding before connecting the top leads or the finish of the coils to the commutator). Put one lead of a test lamp on a bar and move the other lead slowly around the commutator, being sure to contact all the bars as the lead is passed around. Test each and every bar or coil in this manner until every bar or coil has been tested with the other bars or coils.

While this test will not show a short circuit in an individual coil, it will show up a short between two or more coils or bars, and should the lamp light, trace the coils out and remove the short by putting a piece of insulation between the coils where they cross or touch each other.

TESTING AN ARMATURE

Using a growler is a good way to test an armature and the only objection to it is that A. C. current is necessary to use it.

A growler is nothing more than a number of laminations cut and assembled so that when an armature is placed in the opening, the winding on the growler is the primary of a transformer, and the armature winding is the secondary.

Place the armature to be tested in the growler as per Fig. 1, turn the A. C. current on, pass a hack saw blade slowly back and forth from left to right over the slots of the armature, keeping the saw blade horizontal with the shaft and as close as possible to the armature. If the armature does not attract the blade turn the current off and turn the armature as many slots as have not been touched on the bottom by the growler. Turn the current back on and continue the previous procedure, until the entire armature has been rotated and tested. A short circuited coil shows up by a very distinct, strong pull on the saw blade at the slot the short circuited coil lies in. This condition may exist either in the top or bottom coil. Mark the slot with a piece of chalk and turn the armature to right or left for as many slots as one coil spans and make the test again. If there is no pull turn it in the opposite direction and make the test again. When the coil is located that is shorted, examine the bars carefully where the coil is connected to the commutator. If the short is caused by commutator trouble look for metallic particles between the bars.

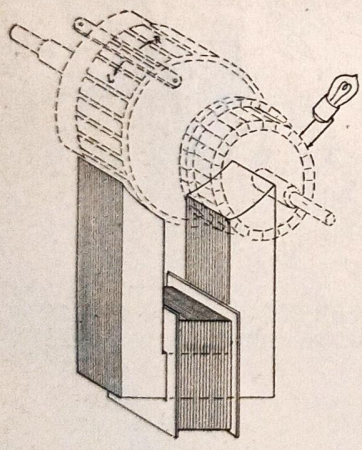


FIG. 1.

The short could be caused by one or more turns of a coil contacting each other from poor or damaged insulation, or two or more coils contacting each other for the same reason, two coils or turns grounded, or wrong commutator connections.

Another way to test with a growler is to use a low voltage lamp (flashlight or auto lamp) with two prongs soldered on it at its terminals, and by making a bar to bar test with lamp while the armature is in the growler and each coil is in the same position. The lamp should burn with the same intensity on all the bars. Be sure that the lamp stays in the same position and all the coils are tested when they are in the same relation to the magnetic field of the growler.

A short shows dim or no light.

Bad connections or open at riser shows no light or a very bright light, possibly burning out test lamp.

CHAPTER III

Motors

¶ 1—¼ H.P. 110 VOLT 60 CYCLE A. C. SYNCHRONOUS MOTOR USING NORTH EAST TYPE G OR GA GENERATOR

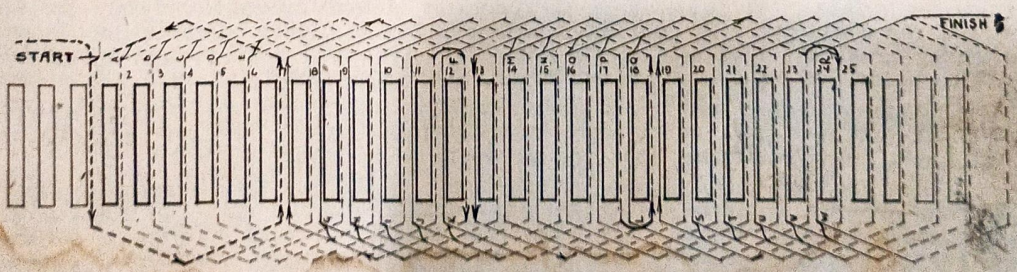
THE Dodge generator can be changed to a combination machine that can be utilized for many purposes. One of which is a 110 volt A. C. motor. The first step is to devise a means of starting the motor. With alternating current, while there are other means of starting, the most practical way is to start it as a series motor. This necessitates a winding on the field coils as well as an armature winding exactly the same as a D. C. winding.

There are a few factors to take into consideration before deciding which is to be used. By utilizing the original shunt or small winding of the Dodge field coils which is 60 turns of No. 15 Plain Enamel magnet wire, it is possible to start the motor with a current of about 18 amperes. As the torque or starting power of the motor is in direct proportion to the amperes drawn, it is up to the builder to decide whether to sacrifice power to cut down the initial amperage drawn by the motor. By using the original shunt winding, all in series, the motor would draw only 18 amperes as previously stated, but would have a starting torque of about ¼ horsepower.

To increase this starting torque, the fields could be wound with 40 or 30 turns of No. 15 Plain Enamel magnet wire. However, it is not advisable to make the field winding with less than 30 turns, as this would draw 45 amperes and would necessitate connecting the starting circuit ahead of the 30 ampere fuses used in the ordinary light supply.

After deciding what the starting torque would be required or desired and if the original shunt winding is going to be used, remove whatever number of turns will give the proper torque. Make a form that the original coil can be placed on and wind on top of the No. 15, 1 pound and 8 ounces, or 500 turns, of No. 21 plain enamel wire. If you already have a 500 watt, self-excited machine made that you wish to use as a 110 volt A. C. motor, it will not be necessary to rewind the armature. However, for best results, it is advisable to wind the armature with 6 turns per coil of No. 18 cotton enamel wire, using the original coil span and commutator connection as shown for the D. C. layout of the Dodge generator in the Figure 1, page 22.

After putting on the D. C. winding, wind the A. C. with 2½ pounds No. 16 heavy enamel wire. It will be necessary to use a distributed winding as shown in ished in slot 7, move to slots 2 and 8 at "A" and wind the next coil in slots 2 and Figure 29. Starting in slots 1 and 7, wind 12 turns, and as the 12th turn is finished in slot 7, move to slots 2 and 8 at "A" and wind the next coil in slots 2 and 8. When this coil is finished, move from slot 8 to slot 3 as at "B" and wind another coil in slots 3 and 9. Then move from slot 9 at "C", winding another coil in slots 4 and 10. At the finish of the coil, at 10, move to "D" through slots 5 and 11, and wind another coil. Upon finishing the coil at 11, move to slots 6 and 12 at



A.C. LAYOUT OF A DISTRIBUTED WINDING FOR 25 SLOT DODGE ARMATURE

FIG. 1.

"E" and wind another coil of 12 turns, keeping the direction the same, and as the 12th turn is put in slot 12, reverse the direction of winding by moving the wire from slot 12 to slot 13 at "F" and wind 12 turns in the opposite direction from slot 13 to 7.

When the 12th coil is finished, move to slot 8 as at "G" and wind the coil in slots 8 and 14, moving to slot 9 at "H". Wind the coils in slots 9 and 15, finishing the coil at "I" and wind a coil in slots 10 and 16. Finish this coil at "J" and winding another coil in slots 11 and 17, finishing at "K."

Wind another coil in 12 and 18, finishing the coil in 18. Reverse the direction by moving from slot 18 to 19 as at "L" and winding the next coil and groups of coils in the opposite direction starting the first one in slots 19 and 13, finishing the coil at "M" and starting the next coil in slots 14 and 20. Finish the coil at "N", starting another coil in slots 15 and 21, finishing the coil at "O", move to slots 16 and 22, finish this coil at "P". Move to slots 17 and 23, finish this coil at "Q", moving to slots 18 and 24.

Upon completion of the coil in slot 24, reverse the direction by winding the wire through slots 25 and 19 at "R", and finish this coil at "S". Move to slots 20 and 1, and the end of the coil will lay on the top of the first coil that was put in the armature. Wind this coil and move to slot 21 at "T" and wind in slots 21 and 2, finish the coil at "U", moving to slots 22 and 3, finish this coil at "V", moving to slots 23 and 4, finish the coil at "W". Move to slots 24 and 5, and finish the coil through slot 24. This finishes the A.C. winding, and the 2 ends of the winding, or both wires can be brought out to a collector ring to be contacted by the brushes supplying the A. C. current.

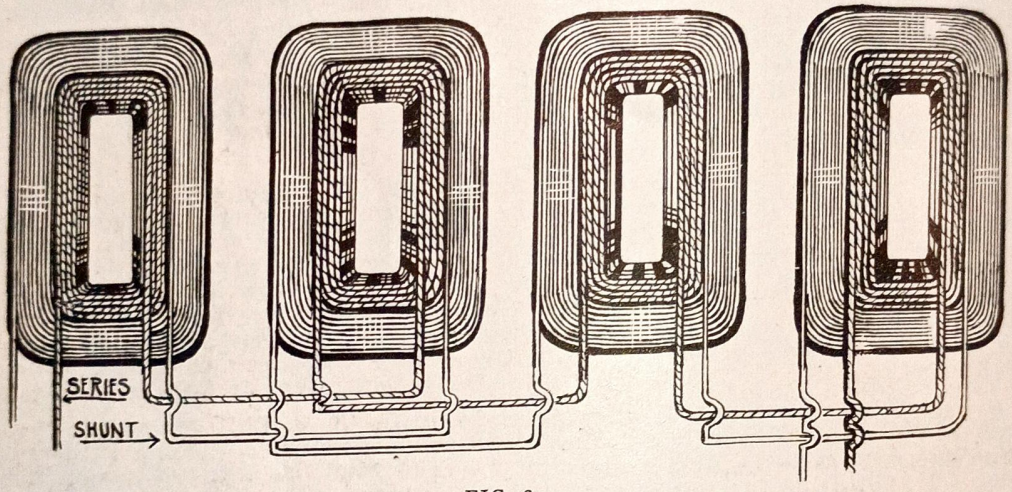


FIG. 2.

But to be sure, put a test lamp across the wiring and the conduit or water pipe. The wire that does not light the lamp is the one to be connected to the frame of the motor.

This machine then becomes a synchronous motor that runs exactly 1800 revolutions per minute. It is also a D. C. generator, delivering approximately 10 volts between the variable brush and one stationary brush and 32 volts across the two stationary brushes. This machine is not only useful for running other machinery, but also becomes a D. C. generator with a voltage from 10 to 32 volts.

Do not expect to make this machine and be able to make it operate satisfactory until you have done considerable experimenting to get the exact adjustments. There are a few adjustments that are necessary to be made.

First, test the machine as a series motor. If the direction is not satisfactory, it can be reversed by transposing the field connections, one with the other at the switch and stationary brush. Assuming that the direction of rotation is satisfactory, the next step is to make sure that the D. C. winding is working satisfactory. Disconnect the A. C. current by putting the 3 pole, double throw switch in a neutral position as shown in the photograph and connect a battery across the field leads at "A". Then disconnect the battery and throw the switch over to the starting position. After it has attained the 1800 revolutions per minute, which after a few at-

tempts will be readily recognized by the sound of the motor which is a hum similar to any motor or generator traveling at this speed, throw the switch over to the run position. If the motor does not function, it is due to two reasons. First, that the speed was not high enough when the switch was thrown or that the D. C. end is not functioning properly.

PUTTING A SQUIRREL CAGE IN THE FIELD POLES

While this machine will run as an A. C. motor without the use of a squirrel cage, a great improvement can be made in its performance by putting in the squirrel cage to keep it from hunting or making a humming noise that is caused by the armature trying to locate its field.

In experimenting with this machine, the first squirrel cage was made by sawing slots in the faces of the pole pieces to take No. 10 and No. 15 bare wires. These slots should be deep enough so that the wires are below the face of the slots and should be snug or a tight enough fit so that the wires or bars are driven into the slots flush with the pole faces. The outside ring that connects all of the bars in the squirrel cage together, can be made from the wire that is in the heavy winding of the original coils, and also the bars can be made to go between each pole piece out of this wire.

All the bars should be soldered to this ring that will connect the entire squirrel cage together. In making the coils, space can be allowed for the ring and bar or the bars can extend out over the field coil and then be soldered together. In soldering the ring to the bars, place a piece of fibre or heavy cardboard between the field coil and the point to be soldered to keep any of the solder or the heat from going into the coils.

A good solder joint is absolutely essential and care and patience should be exercised in this job. The squirrel cage that is shown in the figure is made by milling the pole pieces for No. 6 square wire. The depth of the slots are slightly deeper than the diameter of the wire, and a No. 6 square wire is used for a ring to connect the entire squirrel cage on both sides together.

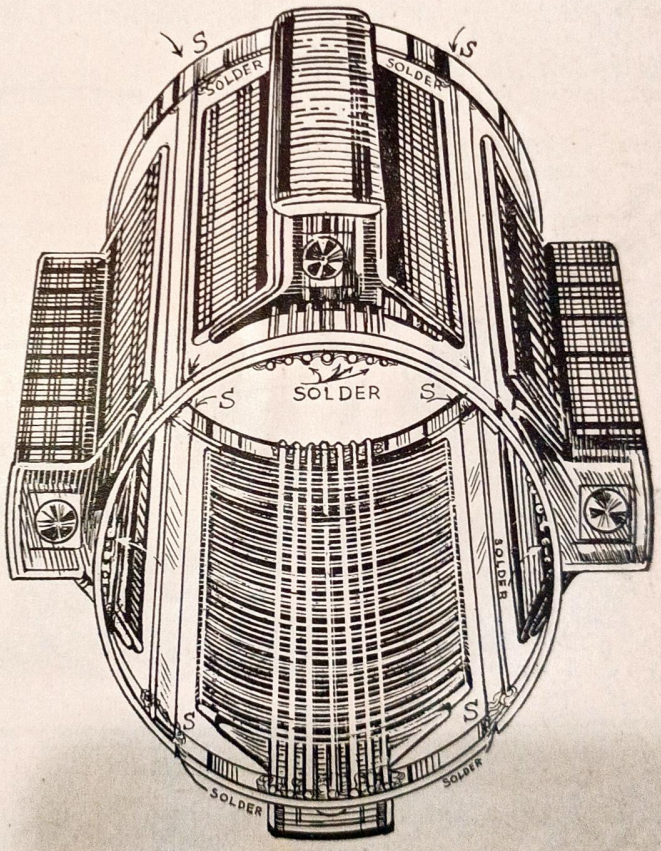


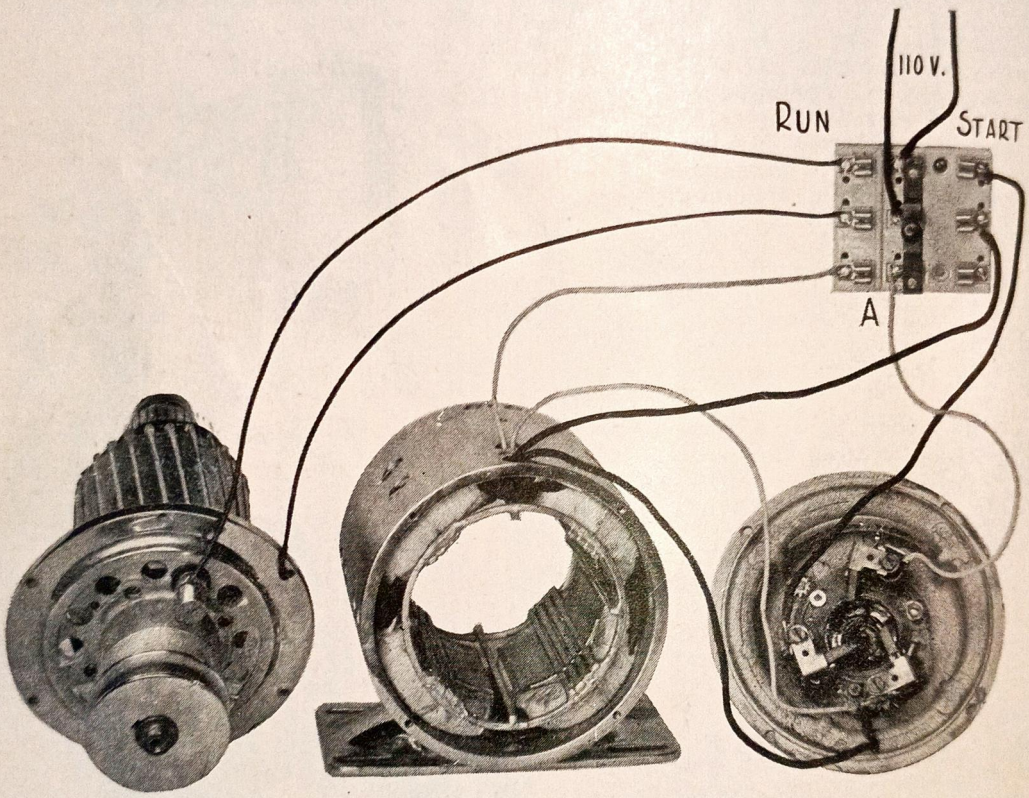
FIG. 3.

The field coils are all connected in series as per Figure 2, and the ends of the coils are connected as shown in the photograph or exploded view of the entire machine. The black wires going from the right of the switch are the series or starting circuit. One end of series winding will connect to one side of the A. C. line. The other end of the series coil will go to a stationary brush, through the armature out to the other stationary brush, and to the other side of the line.

The shunt coil, which is made from No. 21 heavy Formvar magnet wire, is shown in white wires and connected, one to one of the stationary brushes, through the armature to the adjustable brush to the bottom of the 3 pole, double throw switch at "A", through the double pole switch to the other side of the field. It is readily seen that the shunt winding is open to start the machine.

In starting the machine, the switch is thrown to the start position which passes the current through the field coils and the armature as already outlined. When the speed of 1800 to 2000 revolutions per minute has been attained, the switch is thrown to the run position, which automatically closes the shunt circuit, and throws the alternating current on to the A. C. winding of the armature, through the brushes or through one brush and the frame of the motor to the grounded side. If this system is used instead of two brushes to a collector ring, be sure that the brush connected to the frame is the grounded side of the line which is generally shown by the use of a white wire in the wiring of a building.

Try it again by waiting until it reaches a higher speed before throwing it over to the run position. If it does not act satisfactory then, try reversing or transposing the shunt leads or white wires at the brushes or if there is a motor available, drive it in the direction of desired rotation with the switch in the neutral position, running from the variable brush to the switch blade, but disconnect the wire and connect it to the end of the shunt coil that is connected to the female part of the switch. Or, in other words, make a closed circuit of the shunt winding across the



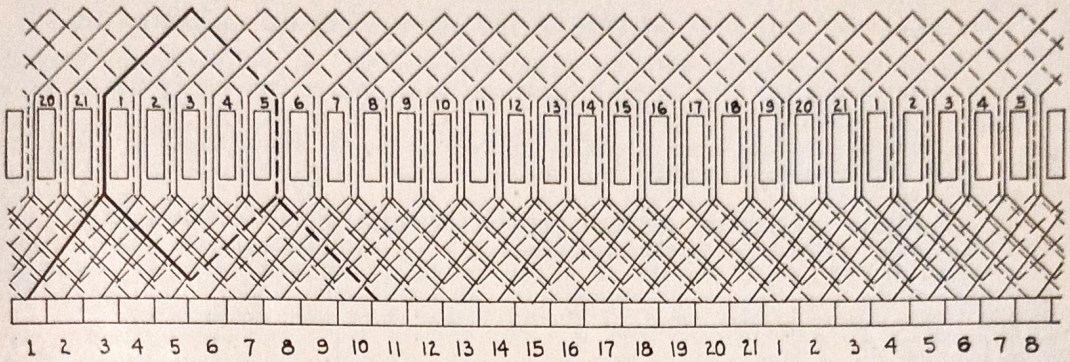
Exploded View of Motor and Connections

variable brush and one stationary brush through the armature. Drive the motor and make adjustments on the stationary brush or any changes that would be made to a D. C. generator to get it to operate. After the D. C. is operating satisfactory, let it run for a few minutes to energize the pole pieces thoroughly. Then disconnect the connection at the switch and reconnect it as it originally was.

Then start the motor again, waiting until the speed is over 1800, and throw it back in the run position. When it is operating, adjust the variable brush until the hum or hunting noise is reduced to a minimum. The stronger the D. C. field is, the less apt this motor is to pull out. However, there is a saturation point that can be reached in this respect. When operating as an A. C. motor, it has the following characteristics: it draws approximately 8 amps. and develops .66 of a horsepower at 1800 R.P.M.

¶ II—6 VOLT D. C. MOTOR USING MODEL T FORD GENERATOR

Wind the armature with 3 turns per coil of No. 13 single cotton enamel wire, using the original coil span and commutator connection as shown in the layout. Fig: 2.



D.C. LAYOUT MODEL T ARMATURE

The field coils for the 6 volt motor are wound with 35 turns per coil of No. 14 plain enamel wire. The weight for the 4 coils is 1½ pounds. The inside wires or the starts of all the coils are connected together as per fig. 9.

The finish of the coil one is run directly to one of the stationary brushes. The finish of coil 2 is run to the female side of a single pole, double throw switch. The finish of coil 3 goes to the blade of the single pole, double throw switch. The finish of coil 4 is connected to the negative side of 2 batteries which are connected in parallel. The start of coil 2 is also connected to the blade of a single pole, single throw switch.

To operate the motor at slow speed, the double throw switch is thrown to position "A." For higher speeds, it is thrown to position "B" and the switch "C" is closed. This automatically connects the fields in parallel to increase the power.

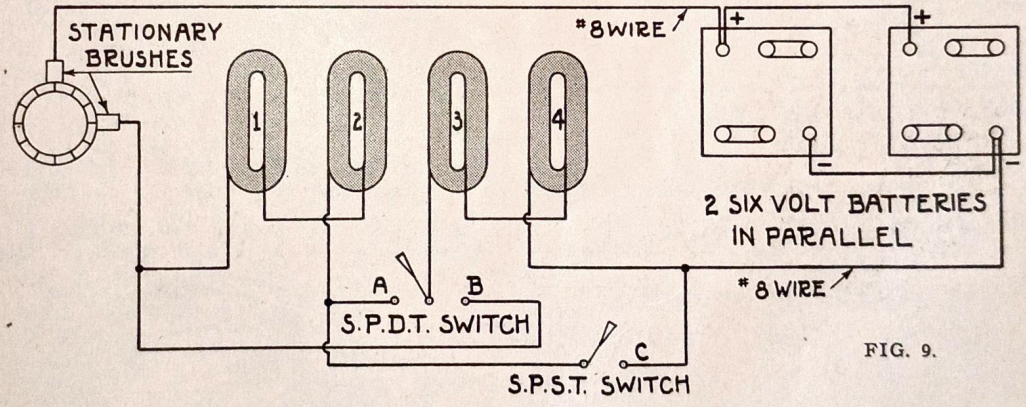


FIG. 9.

¶ III —32 VOLT D. C. MOTOR USING MODEL T FOR GENERATOR

Remove the small or regulating brush (IT IS NOT USED IN THE MOTORS) and apply 6 volts to the other two brushes. If the armature rotates, turn current off. Loosen the four screws on the outside of the generator around the bearing housing, and shift the brushes to right or left about ⅛". Put the current on the brushes again. This procedure should be carried out until the armature will NOT MOVE when the current is applied. The neutral point generally is just where the right edge of the brushes (looking at the commutator end) is just about in the center of the pole piece.

Dismantle the generator, remove the fields and wind a new set of field coils with ⅛ lb. per coil No. 26 Plain Enamel magnet wire.

To reduce the speed to 1200 R.P.M. wind the fields with 25 P. E. THERE IS NO CHANGE TO BE MADE TO THE ARMATURE. Connect one of field leads to one of the brushes and the other field lead to the other brush. Connect the 32 volt line, one side to each of the large brushes, and the motor will develop about 1/6 H.P. at 1800 R.P.M.

¶ IV—110 VOLT D. C. MOTOR USING MODEL T FORD GENERATOR

Wind the armature with 40 turns per coil No. 24 Single Cotton Enamel magnet wire, using the original coil span and commutator connection as shown in the D. C. layout for the 6 volt motor.

The field coils are wound with $\frac{5}{16}$ lb. each of No. 31 Plain Enamel. Tape the coils with .007 varnished cambric tape with a layer of cotton tape over the varnished cambric tape.

CAUTION: BE SURE ARMATURE IS NEUTRALIZED BEFORE CONNECTING TO LINE. Otherwise it will arc from one brush to the other. Watch grounded side of motor and line, if one side of power supply is grounded. Connections at the brushes are the same as the 32 volt motor. It will develop about 1/6 H.P. at 2200 R.P.M. For lower speeds wind field with larger wire and less turns.

CHAPTER IV

Electric Welding

WELDING GENERATOR THEORY

IN any consideration of the construction and operation of arc welding generators, some space should be given to the study of the electric arc welding process itself. An electric arc is formed whenever two conductors are separated after they have been in contact as a part of a closed electrical circuit so that a current is flowing from one to the other. If the circuit is such that the current which continues to flow between the two conductors is greater than a certain critical value, the arc will be maintained, and the current will pass through the air and vapors between the two conductors, which are now acting as electrodes. While the arc is maintained, a large amount of electrical energy is converted into heat in a small space, so that a very high temperature is developed.

In welding practice, an arc is formed between the piece of metal to be welded and a small metal rod. The large amount of heat concentrated at the arc causes part of the metal being welded to melt; at the same time part of the metal rod is melted and deposited in the pool of molten metal on the work. Thus, it is possible to obtain an entirely homogeneous weld formed by the mixture of the metal from the rod and that of the work. In order that the weld produced may be as uniform and strong as possible, it is desirable that the heat in the arc and, hence, the electrical energy dissipated in the arc be as nearly constant as possible.

During the actual welding process, the distance between the rod and the work is constantly changing, because of the unsteadiness of the operator's hand, the melting away of the rod, and other causes within the arc itself. This variation of arc length tends to cause similar variations in current. It has been found, however, that the voltage across a metallic arc is practically constant throughout the range of currents ordinarily used in welding. A curve showing the variation of arc voltage with the current would be of the form shown in Figure 1. Then, in order that the heat energy in the arc may be constant, it is desirable that the current in the arc be maintained as nearly constant as possible. Most welding generators are, at present, designed to approximate the condition of constant arc current.

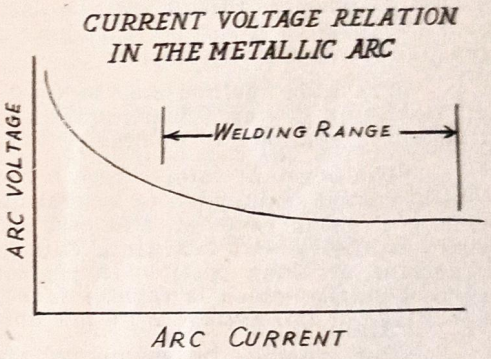


FIG. 1.

There are two main types of direct current welding devices in common use; namely, the constant voltage and the variable voltage. In the constant voltage type,

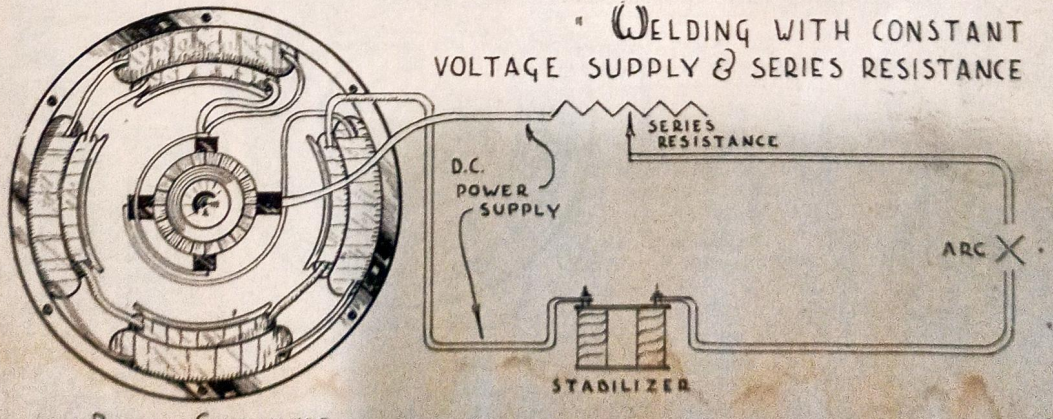


FIG. 2.

a simple, flat-compound generator is used. The arc is operated in series with a resistor directly across the terminals of the machine as shown in Figure 2. Then, when the arc is in operation, part of the energy is dissipated in the resistor and part of the arc. When the current in the arc decreases, the voltage drop in the resistor decreases, causing a greater voltage to be impressed across the arc since the sum of the arc voltage and the resistor voltage is constant; similarly, when the current increases, the voltage across the resistor increases and that across the arc decreases. This action results in a tendency to adjust the arc to nearly constant current. The relation of arc voltage to arc current would be similar to that shown in Fig. 3.

The welding generator described in the book **Autopower** is of the constant voltage type. It is designed to deliver the maximum possible power to the arc for the size of the Dodge generator frame. It has a constant terminal voltage of 25 volts and is capable of delivering 60 amperes. In order to be used to do welding at 20 volts, it is necessary to have some resistance in series with the arc. For welding with the maximum current, the resistance of the leads and stabilizer are sufficient. But for light welding on sheet metal, lower current is required. This may be obtained by holding a long arc, but the quality of the weld will then be impaired. Instead, a series resistance should be used. This may be wound of iron resistance wire having a crosssection large enough to carry the current. If, for welding on light gauge sheet iron, it is desired to use a $\frac{1}{16}$ inch rod with a 25-ampere, 20-volt arc, the voltage drop required is 5 volts, and the total resistance required is $5/25 = 0.2$ ohm. Similarly, the resistance required for any current is 5 divided by the current.

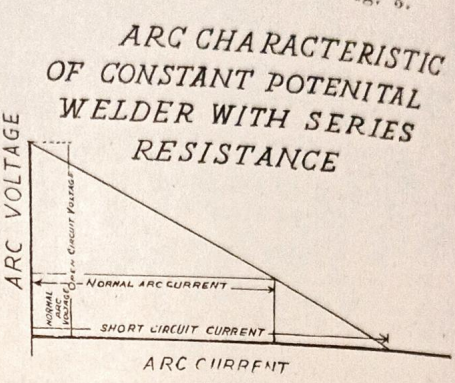


FIG. 3.

The same method may be used to calculate the resistance for welding across a 110-volt D. C. line. The voltage drop desired in the resistance is 90 volts, so the resistance required for welding with 45 amperes is $90/45 = 2$ ohms.

The constant voltage type is used in commercial multiple operator sets, from which current is supplied to several operators at one time, the voltage output of the generator being constant, and each operator having his own set of leads and a resistor in series with his arc. This type of equipment does not require a special generator, it being possible to operate across any suitable constant voltage direct current supply which is capable of supplying the required current. The chief disadvantage of this system is its low efficiency.

For example, in commercial multiple operator sets, the generator voltage is usually about 60 volts; when a bare metal rod is used, the arc voltage is about 20

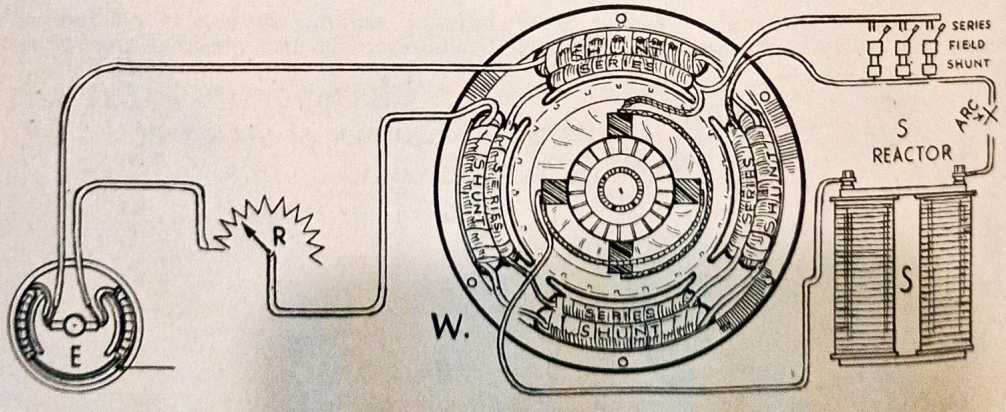


FIG. 4.

volts. The efficiency, or ratio of the power used in the arc to that developed in the generator is

$\frac{20\ I}{60\ I}$ = 33 per cent. When this system is used across a 110 volt line, the efficiency is only $\frac{20\ I}{110\ I}$ = 9 per cent. In other words, most of the energy for which the consumer pays is being used to heat the air about the resistor instead of the metal being welded.

The more generally used device is the variable voltage, single operator welding generator. The voltage on open circuit in this type of machine is usually about 70 to 80 volts, but when the arc is struck, so that a load is put on the machine, the terminal voltage drops in value at a much greater rate than would a similar cumulatively compounded or simple shunt generator. The means of achieving the desired characteristics in the generator is the subject of many patents and claims.

The simplest method, probably, is to use a separately excited differentially compounded generator. The connections are shown in Figure 4. The purpose of the exciter, E is solely to supply current to the shunt field of the welding generator W. It is simply a small, self-excited D. C. generator whose voltage and current output are correct for the fields used in the welding generator. The field current is adjustable by a field rheostat, R. The current in the welding circuit passes from the armature through the series fields to the arc and returns through the stabilizer, shown at S, to the armature. The series field is provided with a set of three or four shunts, or low resistance conductors, some or all of which may be connected across its terminals so that all or only part of the welding current may pass through the series field. The series field is so connected that its magnetizing action is in the direction opposite to that of the shunt field.

The action in the generator is as follows: When the machine is started up, the exciter voltage builds up so that current passes through the shunt fields of the welder. An emf. of about 70 to 80 volts is then generated in the armature of the welder. When the arc is struck by touching the welding electrode on the work, a heavy current tends to flow in the welding circuit. The initial surge of current is damped out by the stabilizer, which will be explained later. The current which flows to the arc must pass through the series field, whose magnetizing action opposes that of the shunt field. The effect of the passage of this current through the series field is the same as would result from reducing the current in the shunt field; the effective flux through the field structure and armature is reduced. This results in a reduced terminal voltage. The machine is so designed that the terminal voltage drops to about 20 volts when the current through the armature is that desired at the arc. The relation of arc voltage to arc current with this type of machine is shown in Figure 5.

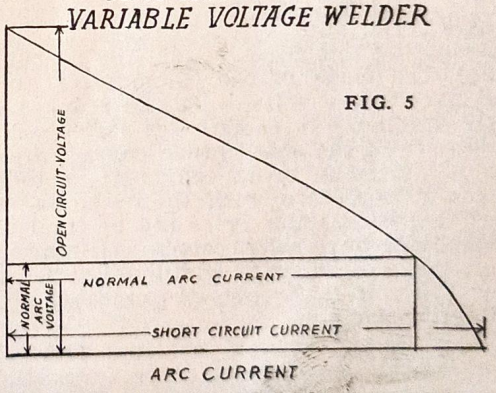


FIG. 5

When, in the process of welding, the current starts to increase, the excitation of the series field increases, causing a drop in the terminal voltage of the machine; this would tend to prevent further increase in arc current. Similarly, when the arc current starts to decrease, the series field excitation decreases, causing less bucking effect and a higher terminal voltage; this tends to prevent further decrease in arc current. Thus, it is readily seen that the machine operates so as to adjust itself toward more nearly constant current.

There are two means of controlling the arc current. First, part or all of the shunts may be connected across the series field. When all of the shunts are disconnected, all of the arc current passes through the series field, so that a minimum amount of arc current is required to reduce the terminal voltage from a given open circuit voltage to the required welding voltage. When one of the shunts is connected across the series field, only part of the welding current passes through the field, so that a higher welding current than before is passed before the voltage is bucked down to 20 volts. The current which is supplied at 20 volts may be increased by connecting more low resistance shunts across the series field, the only limit to the current which can be supplied being the capacity of the armature winding. The second means of controlling the welding current is the field rheostat. The rheostat raises or lowers the open circuit voltage, thereby giving various currents for any given setting of the series field shunts.

This type of machine is fairly efficient and has good operating characteristics, so that very good welds may be produced. The chief disadvantage is that the output from a given frame is rather small because of the weakening of the fields under load. Use of the separate excitation is necessary because, if the machine were self-excited, the shunt field excitation would die out when the welding was being done. With a decrease in shunt field strength, the voltage recovery would be very slow and the arc would be hard to hold. In locations where a D. C. line is available, the welder fields may be excited from this line.

There are many ways in which old generators may be changed over into welders of this kind. For example, we have a question concerning the use as a welder of a 40 volt, 80 ampere generator, originally a farm lighting plant. The shunt fields could be connected two series-two multiple and excited through a rheostat from a 32 volt farm lighting battery or generator, or else left connected in series and supplied from a 110 volt D. C. line through a higher resistance rheostat. The field should be operated with more current and the speed increased so as to give an open circuit voltage of 60 to 70 volts. If necessary, a small exciter could be built from an automobile generator.

This machine could supply up to 100 amperes, at least for a moderate length of time. If 45 to 50 amperes be considered the short circuit current with no series field shunt, this will give around 35 amperes at 20 volts as the lowest setting. The number of turns in the series field would be the number of ampere turns in the shunt field divided by 45. Special care should be used to make sure that the series field is connected to buck the shunt field. The wire should be large enough to carry the fifty amperes. To get more than 35 amperes at the weld, wire resistances would be connected across the terminals of the series field until the welding current reaches a maximum of around 120 amperes. Whenever a machine has its shunt field strengthened and its speed increased in this way, it will run hot with no load, so it should not be allowed to run without load for long periods. Because of the weak field used under load and the absence of interpoles, considerable sparking will take place and should be expected when the machine operates under heavy load. To reduce this sparking advance the brushes in the direction of rotation as far as possible without causing excessive sparking under no load condition.

In similar manner, almost any 32 volt farm lighting generator could be used as a welder by separately exciting the shunt fields from an external source, using a higher field current than was normally used before, connecting the fields in multiple if necessary, and speeding up the driving motor until the open circuit voltage is around 55 to 70 volts. A series field must then be used to reduce the voltage under load, as explained before.

Many D. C. motors and generators with voltages of 110 to 130 volts may be used, also, with a few changes, provided the machine is of four pole construction. Assuming this construction, the probability is that the armature is wave wound. If, not, the leads to the commutator are all lifted and reconnected as a lap wound armature, the voltage will be reduced and the current capacity of the armature will be doubled. In some cases considerable heating of the commutator may take place because of the small brush contact area, but the heating may be kept within reasonable limits by using judgment as to operating time. The series winding will be wound as before, with shunts so as to provide a maximum welding current somewhat greater than twice the original rated current of the machine. Many of these machines have series windings already, in which case they can be used, either alone or, more often, with additional series turns. The fields may be excited from a 110 or 120 volt D. C. line, or connected all four in multiple excitation to a 32 volt farm lighting system.

If the 110 volt machine is bipolar, or if it is four pole but the armature is already lap-wound, the current capacity of the armature cannot be increased without rewinding with larger wire. In case the rewinding is done, use wire three sizes larger, and use one half as many turns, armature connections being the same as before. If the owner does not wish to get the maximum current from the machine, he may simply weaken the field or lower the speed until the open circuit voltage is around 70 or 80 volts, and then provide a series field, as before. Machines built for 220 volts may also be rewound, but they usually have rather small commutators so that considerable heating would take place.

The stabilizer was referred to several times previously. The purpose of this device is to slow up any sudden changes of current during the welding process. At the time when the arc is struck, it prevents a sudden rush of current during the short time when the generator is adjusting itself to the load condition. If the operator's hand should shake, so as to lengthen the arc for a short time, the stabilizer

helps to prevent the arc current from stopping. The principle and construction of the stabilizer are similar to those of the alternating current transformer. The stabilizer consists essentially of a coil of wire which carries all of the arc current, wound upon an iron core. Then, whenever the current through the coil is changing, an emf. is induced in the coil in the direction which would oppose the change of current flow. Then, when the arc is first struck, a voltage exists in the stabilizer which opposes the generator's voltage, so that the arc tends voltage at the arc is less than that at the generator terminals. Also, when the arc tends to break, the voltage at the arc is greater than the terminal voltage of the generator.

The building of a satisfactory stabilizer for light and medium size work is described on Pages 36 and 37. This may be used continuously for currents up to 60 amperes and for considerably higher currents for short periods. When higher currents are used continuously, this frame may be rewound with heavier wire. It may be worthwhile, in some cases when heavy currents are used, to obtain an old or burned-out transformer of three kilowatt size or larger, putting on a new winding of size six or four square wire in place of the old coil, the wire size being chosen so that about 350 to 450 circular mils per ampere of welding current. The laminated structure of the transformer gives somewhat better stabilization for a given size.

REACTOR CHARACTERISTICS

An iron core reactor which is ordinarily used as a stabilizer in direct current welding circuits is probably the most efficent means that could be employed for that purpose. Where efficiency is not of importance, an adjustable series resistor will improve the stability of a fluctuating circuit. It will have the advantage of instantaneous action with the corresponding disadvantages of lowered efficiency of the circuit in that the drop across the ballast resistor will be a net power loss in direct proportion to the amount used at the arc.

By comparison the reactor is highly efficient in that it does not depend on a variable drop across it for its stabilizing action, but rather on the energy stored in it in the form of magnetic lines of force or flux. The flux is set up in the core by the current flowing from the generator through the reactor coil across the arc and back to the generator and as it is only while the amount of flux in the reactor is changing that the reactor has any influence on the flow of current in the circuit, the overall efficiency is hardly affected.

When the circuit is first closed, as for instance by the striking of the arc, the rapid increase of the flux in the reactor core sets up an opposing effect in the coil which retards the flow of current in the circuit.

This opposing action will only be effective as a current limiting influence, while the flux in the reactor core is still increasing. When the reactor core is fully magnetized, it will no longer retard nor hinder the increase of current flow in the circuit.

As the arc is drawn, the current in the circuit is decreased rapidly and the corresponding rapid reduction of reactor flux now acts opposite to what first took place. Instead of retarding the flow of current it will now set up an effect in the coil, which is in the same direction as the current in the circuit, and in that way will tend to maintain an unbroken arc.

Thus the action of the reactor is much like the effect a flywheel has on a revolving shaft. If the shaft is at a standstill, it will take more time and power to bring it up to full speed with the flywheel attached than it would take if the shaft had none. The extra power required to bring the shaft up to full speed is stored in the flywheel in the form of momentum, and when the driving force is reduced or shut off, this store of energy tends to keep the flywheel and shaft revolving at the previous rate of speed.

While the power applied to the drive pulley remains steady, the flywheel has very little effect on the speed of the shaft, and it is only while speed is changing, either increasing or decreasing, that the flywheel has any stabilizing effect. In other words, it opposes any change in a given condition.

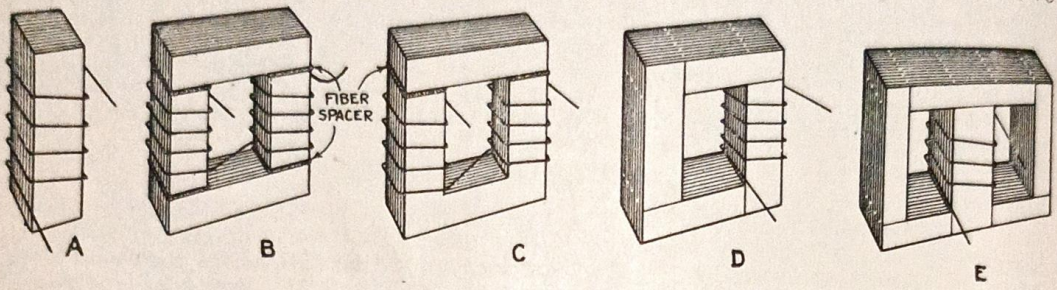
REACTOR CORE DESIGNS

The form of design used in making a reactor would depend on what action best suits the kind of work to be done. The kind of core material used also has an effect on the action the reactor will produce.

The cores can be either a straight section (A), or two straight sections with a yoke across both ends (B). Or it may be a modified core type either in the form

of a "U" with a yoke across the open end (C), a core type core with winding on one or both legs (D), or a shell type core with winding on middle leg (E). If the "U" type core is arranged so that fibre spacers can be placed between the core ends and the yoke, a ready means for adjusting the action of the reactor will be had.

The straight section types will have fast response, and the duration of the action will be short. If enough extra winding turns are put on to build up a sufficient quantity of flux, the strength of the buck or boost action may be satisfactory. The "U" type and yoke arrangement may be the type most easily adaptable to the average requirement, and it is also more economical as it requires less material for a given amount of flux. With a fibre spacer anywhere from $\frac{1}{32}$" to $\frac{3}{16}$" thick the response will be fast and strong. The shell type or core type without air gap will give



the most action for a given amount of iron and copper, and if the core is made from soft laminated iron, the action will be rapid enough for the average welding circuit. Solid steel cores will not be very efficient, as the resistance set up will be partly retained after the current is reduced. For that reason there will be only part action in either direction.

WINDING SPECIFICATIONS 100 Amp. reactor—60 turns 2 No. 7 D.C.C. Sq. wire on 14 square inch core; 200 Amp. reactor—42 turns of 3 No. 6 D.C.C. Sq. wire on 20 square inch core; 300 Amp. reactor—34 turns 4 No. 5 D.D.C. Sq. wire on 25 square inch core. In figuring the core for the reactor try to keep it square as near as possible. For example: the 14" square core should be 3½" high and 4" wide. A 20" square could" be 4" × 5", 25" square 5" × 5". However, you can deviate from this to match the laminations you may have on hand.

To figure the length of the legs; estimate that six No. 7s could be laid to the inch, and five No. 6s to the inch. The reason that square wire is recommended is that it is much easier to work than the round wire and has a carrying capacity the same as one size larger in a round wire.

¶ II—MAKING THE PERFECT WELD*

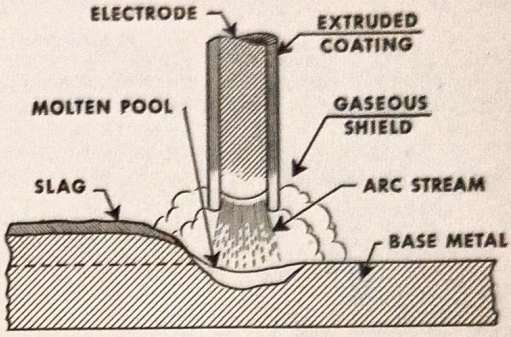
Temperature of the electric arc is beyond the scope of ordinary measuring instruments, and though the exact figure is not known, it has been estimated, by reason of various experimental processes, to be about 3600 degrees Centigrade. This of course, is sufficiently high to cause the fusion of any metal to be welded. A large portion of the heat produced is generated in the positive electrode, in most cases the "work" side of the electrical circuit, and in this arrangement the heat is most effective for melting the metal. Where the flame produced by the combustion of oxygen and other fuel gases is employed to cause fusion, the heat is applied external to the work and is blown on at the point where melting is desired. In metallic arc welding, the electrode is the negative terminal or cathode and the work the positive electrode or anode. The heat being generated to a larger extent in the positive side of the circuit gives a good opportunity for better fusion at the point desired. Melting of the metallic electrode is accomplished through the heat generated in it and that radiated from the positive electrode. In carbon arc welding, where the arc is drawn between the carbon electrode and the metal to be welded, a large portion of the heat is produced in the work and the metal to be added is fed into the arc in the form of a filler rod.

In electric arc welding a higher thermal efficiency is possible due to the fact that in the use of a combustion flame, the heat, being generated outside the work, is partly lost by conduction and deflection of the flame from the point at which molten metal is required.

*Reprinted by permission American Steel and Wire Co.

SELECTION OF ELECTRODES

Metallic electrodes have been proved more satisfactory than carbon electrodes since they require handling by less skillful operators. In metallic arc welding the end of the electrode is melted, the molten metal being carried through the arc and deposited at the other end of the arc on the material being welded, at which point the material is in a molten state produced by the heat of the arc, effecting a perfect union with the newly deposited metal. Equal results can be attained in the carbon electrode method provided the welder is skillful and careful enough to produce uniform fusion continuously. Should this uniform fusion not be accomplished the deposit metal will flow too rapidly onto portions of the work which have not been brought to the molten or fusing state. An important application of carbon arc welding is that field wherein strength is not of as great necessity as the speed of doing the work.



Courtesy of Lincoln Electric Co.

The size of metal electrodes, as well as carbon, depends to a great extent on the size and thickness of the work and the throat of the weld to be produced.

ARC LENGTH

While the length of the welding arc is one of the variables governing the properties of the weld, the correct arc length will not alone guarantee good welds. The plate or work is heated by the release of energy at the terminal of the arc, by radiation and conduction from the arc core and stream and by radiation from the hot surface of the work and the hot metal deposited on it. With a short arc this heat is concentrated on the plate, whereas with a long arc a grea deal of it is lost into the surrounding space. Consequently, with a short arc a greater portion of the energy is transformed into useful heat.

A long arc is not as stable as a short arc and tends to wander about over a considerable area on the plate, the arc flame blowing about very rapidly. This action, together with the greater length of the arc, affords a great opportunity for the air to come in contact with the metal passing from the electrode to the plate and also in contact with the very hot metal in the arc pool or crater. This results in the absorption of oxygen and nitrogen, both of which are detrimental to the quality of the weld. With a short arc, the flame consisting of vapors coming out of the arc acts as a protection and prevents very largely the absorption of these outside gases.

In general the arc should be held just as short as it is possible to hold it, without causing the electrode to touch the work and interrupt arc actions. Experience will teach the welder to tell by observation when a short arc is being held. It is possible to tell by sound with low carbon electrodes, whether the arc is long or short. If the arc makes a rapid crackling sound that is fairly steady in intensity, the arc is short.

ARC STABILITY

Hand welders find that the welding current flowing in the electrode under some conditions sets up a magnetic field causing the arc to become wild. Slanting the electrode forward or backward has an effect on this condition. Generally speaking, one welds away from the ground connection but sometimes a change in the location of the ground will eliminate undesirable magnetic fields and the arc will become more steady.

PENETRATION

At the point where the arc strikes the plate, assuming that current, polarity and speed of travel are correct, the metal is melted and seems to be forced out of the pool by some sort of blast from the arc. This results in the metal piling up around the edges of a small depression in which the metal is in a molten state. This depression is referred to as the arc crater and its depth provides a means of observing the penetration during welding and to a certain extent of predicting the

soundness of the deposit. The crater depth will depend upon the thickness of the metal but in general should be in excess of $\frac{1}{8}$ inch.

Correct penetration will insure that the metal of the plate is melted and in condition to receive the metal projected from the electrode; also that the area of the crater will be sufficient to receive all the metal deposited from the electrode and not permit any of it to overlap on the solid metal of the plate where it will not stick.

WELDING CURRENT

It is difficult to give universally applicable figures covering current, speed, etc., for electric arc welding, due to the effect of conditions under which the work is done, the character of the work and, to a very large extent, the skill of the operator. The same size electrode may be used with various thicknesses of plates, but the heavier plate will require the use of heavier current.

IMPURITIES

Some impurities affect the weld by weakening it, some by making it brittle and others by making the deposited metal so hard that it cannot be conveniently machined. Gas pockets, slag, oxides, etc., will materially weaken a weld and can be best eliminated by using a short welding arc and by keeping the weld and electrodes clean. Grease and dirt on the surface to be welded or on the electrode, will result in gas pockets or slag inclusions. Brittle and hard welds are often caused by a long arc which permits the hot metal to be exposed to the air with consequent absorption of nitrogen which has been largely blamed for brittle welds. This is particularly true of welds on metal where the carbon content of either the electrode or the work is in excess of .30%. Oil or grease burned into the weld metal will increase the carbon content of the deposited metal and consequently increase the hardness.

In welding with the carbon arc, hard welds may be caused by too short an arc causing carbon to be carried into the weld. Before beginning a weld the work should be thoroughly cleaned by means of a steel wire scratch brush or sand blast to remove scale, and grease should be removed by washing with gasoline and alkalies or a sand blast may be used. As the weld progresses, the metal adjacent to the point at which the arc stopped should be cleaned each time an electrode is changed. This can be done with a scratch brush. Porosity is caused by the inclusion of gas forming material in the weld, the introduction of such being through poor electrodes or poor metal in the work, by excessive heating or by not properly welding over the point where the arc is stopped.

¶ III—WELDING GENERATOR USING NORTH EAST TYPE G OR GA GENERATOR

Dismantle the generator and remove the field coils and brush holders. Clean all of the parts thoroughly with gasoline and let them dry.

Make a new set of field coils. The coils are compound wound having a shunt and series winding. The shunt coil is first wound on the form, using ¾ pound of No. 20 P.E. wire per coil. And after this coil is wound on the form, wrap a piece of armature paper the width of the coil around the coil. Then wind 17 turns of 4 No. 14 S.C.E. wires in parallel (1 pound). This may be done by winding all 4 wires at once or taking 1 wire at a time winding 17 turns, and then another until the 4 wires have been put on. If they are put on singly or together, the ends of this heavy winding are connected together so as to make 1 wire or have the carrying capacity of a No. 8 wire. After these wires have been laid on the shunt winding, tie both of them together and wrap a piece of friction tape around the coil before it is taken from the form.

Tape the coils with one layer of cotton tape lapping the tape half way over the previous turn as the coil is taped.

The coils can be given a preliminary shape by putting them in a large vise between a curved holder placed against one jaw and a piece of pipe or round wood about as large in diameter as the coils are wide. Be sure when forming the coils to form them all on the same side. This can be checked easily by keeping the inside or start of the series winding on top, or press against this side.

Place the coils back into the frame so that both the windings can be connected together properly, and, as the screws are tightened, hold the generator frame in one hand and strike the frame hard with a hammer near the screw. Then with

a punch, drive the screws up tight and continue to tap the frame around the screw until they are as tight as possible.

Connect the small or shunt winding first. Commencing with the finish, or outside lead, put that to one side and connect the start, or inside lead, to the start or inside lead of the next coil. Take the finish of this second coil and connect it to the finish, or outside lead, of the third coil, and the inside lead of the third coil connect to the inside lead of the fourth coil. This leaves two starts of adjacent coils

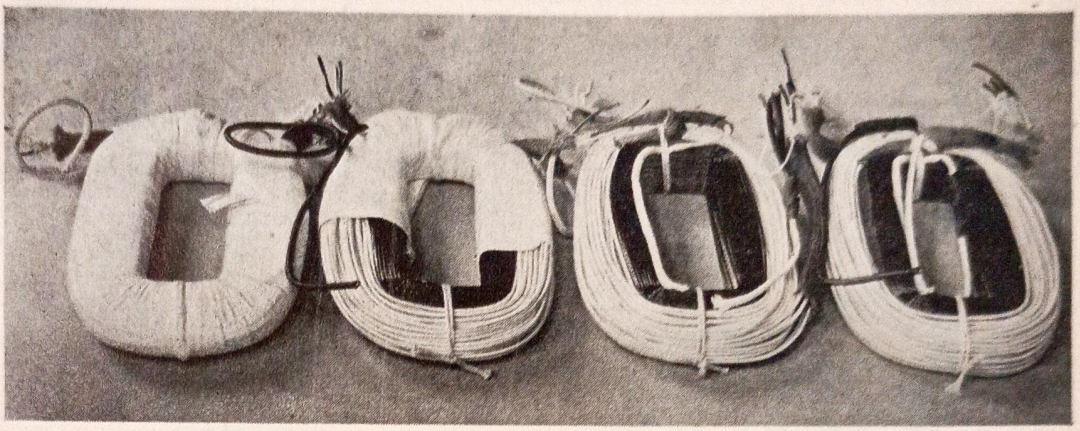
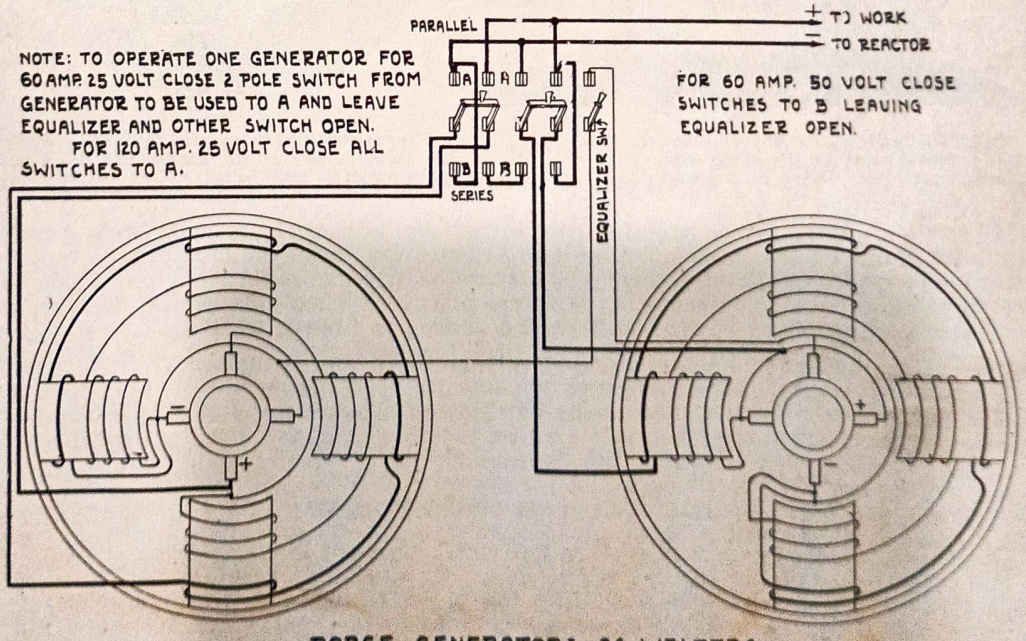


FIG. 11.

for connections. Attach D. C. current to these coils and check the polarity with a compass. If the polarity is right, solder and tape the three connections and bend them back between the coils.

Follow the same procedure in connecting up the series winding and start with the same coil. After they have been connected, solder a piece of No. 8 flexible rubber-covered wire onto the ends of the series winding, and a piece of No. 18 flexible on the ends of the No. 20, or shunt winding, and tie these leads with a piece of cord to the large leads. Leave slack between the coil and where it is tied to the large lead so that there will be no strain put on the No. 20 wire.

Connect the coils to the brushes and line as is shown in Fig. 12. There is no change made in the armature.



DODGE GENERATORS AS WELDERS FIG. 12

The wire necessary for this job would be 3 pounds of No. 20 P.E. and 4 lbs. of No. 14 S.C.E.

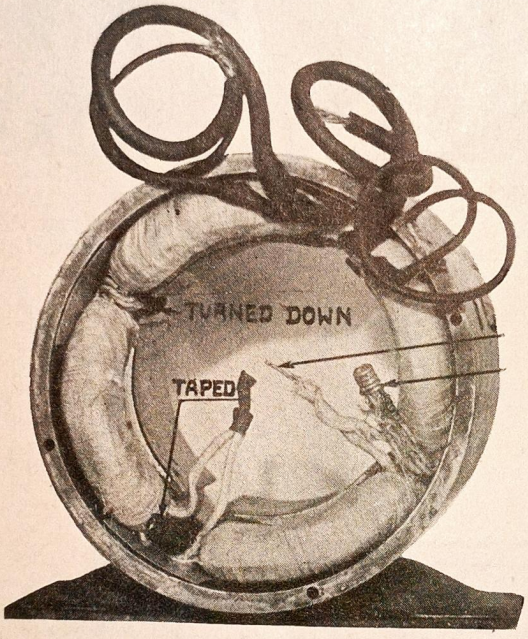
To add to the efficiency of this generator, put 4 one-inch holes around each end of the frame. The holes should be bored on the quarter, half way between the poles. The edge of the holes should be ¼ inch from the end of the frame. Figure 3 H.P. per generator driving speed 2,000 R.P.M.

INSTALLING A FOUR-POLE RIGGING IN THE DODGE GENERATOR

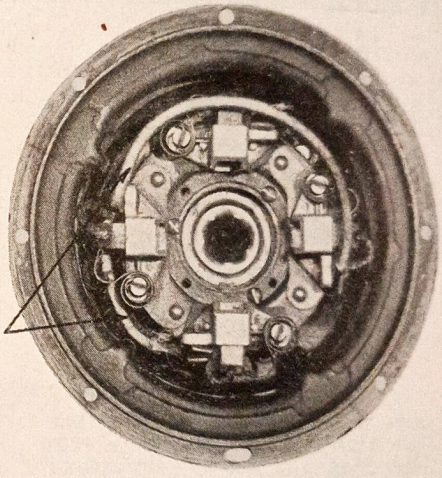
A brush rigging for a model T starter can be placed in the Dodge end housing by following the procedure:

Remove all the old brush rigging and cut the flange that held the old brush rigging in the center, flush with the surface that supported the original rigging. Take the starter rigging and place it so that the brush holders proper will be in the center of the four openings that are around the housing. Then in the center punch three holes so that the new rigging can be supported on the same castings that previously held the old brush holders in place. Drill these holes and tap them for No.

FIG. 13.



NOTICE—How the connections are made. The arrows point to the shunt connection on the left and the series to the right.



The arrows point to the jumpers. Notice the three screws in the center and the 4 new holes opposite each brush.

6-32 screws. This brush rigging can either be left as it is with two brushes grounded and two insulated. Or the two brushes that are grounded can be removed and the projections that formerly held it in the rigging can be cut off, flush with the side holder and two insulating washers placed on each side of the holders, and the holder tapped for two No. 6-32 thread screws to hold it in place.

After the brush holders are securely fastened and insulated (if it is desired to have it insulated), place the entire housing back on the generator, bore new hole in the housing to hold it to the frame so that the brushes are a little past center of the pole pieces. Jumper the brush holders together that are directly opposite from each other. Using No. 8 wire or its equivalent.

THE REACTOR FOR WELDING

Cut 2 pieces of 2-inch cold rolled steel 7 inches long. Drill and tap them in the center of each end for ½ inch standard thread bolts. Insulate the entire piece with 2 layers of armature paper. Lay the paper on tight and glue it. Cut four 4-inch circles from ⅛ inch fibre and make holes in the center just large enough to slip over the steel rod and paper, and a ¼ inch hole in 2 of the rings with the edge

of the ¼ inch hole at the edge of the 2 inch hole. The large hole should be a snug fit to go over the paper. Glue these fibre rings to the paper ½" inch from each end, and wind 6½ pounds of No. 7 D.C.C. wire on each rod, starting the wire through the ¼ inch hole. Put both windings on in the same direction and connect the two starts of the windings together. Use the other two ends in series with the negative line. Use No. 6 rubber covered flexible cable as a feeder to work and electrode. A holder can be made from a ¼ inch brass pipe as per diagram. Use $\frac{1}{16}$ inch or $\frac{5}{32}$ inch welding stock.

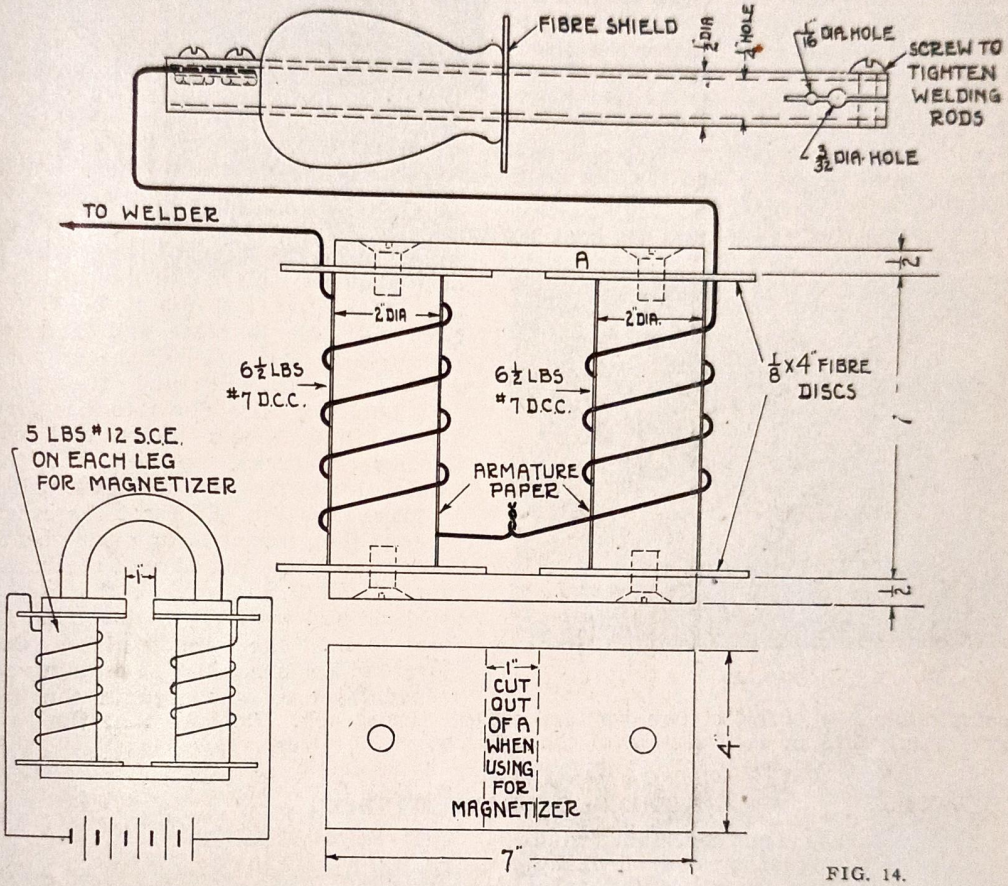


FIG. 14.

REACTOR AND MAGNETIZER

When making up the welder, study carefully Figure 2, page 27, shows how all of the connections are made but the series resistance is not used on small machines. The fields in this drawing are shown as if they were made separately instead of one wound on top of the other. This is done to make the circuits easily understood and is the proper hookup when using one machine.

¶ IV—WELDING TRANSFORMER

A winding form is made from a block of wood $2\frac{1}{16}$"x$2\frac{1}{16}$" long. On one side of the block measure ¾" from the top at one end and ¾" from the bottom at the other end. Draw a diagonal line from these two markings and saw the block in two along this line. After the block has been sawed, clamp it firmly in a vise or clamp and bore a hole through the center large enough to take a mandrel to turn it on.

Cut a piece of .015 insulating paper 7" wide and long enough to make two turns around the form. Wrap a few turns of cotton tape over the paper to hold the paper in place. The beginning of the winding can be held to the core by a small

of the ¼ inch hole at the edge of the 2 inch hole. The large hole should be a snug fit to go over the paper. Glue these fibre rings to the paper ½" inch from each end, and wind 6½ pounds of No. 7 D.C.C. wire on each rod, starting the wire through the ¼ inch hole. Put both windings on in the same direction and connect the two starts of the windings together. Use the other two ends in series with the negative line. Use No. 6 rubber covered flexible cable as a feeder to work and electrode. A holder can be made from a ¼ inch brass pipe as per diagram. Use ⅛ inch or ⅜ inch welding stock.

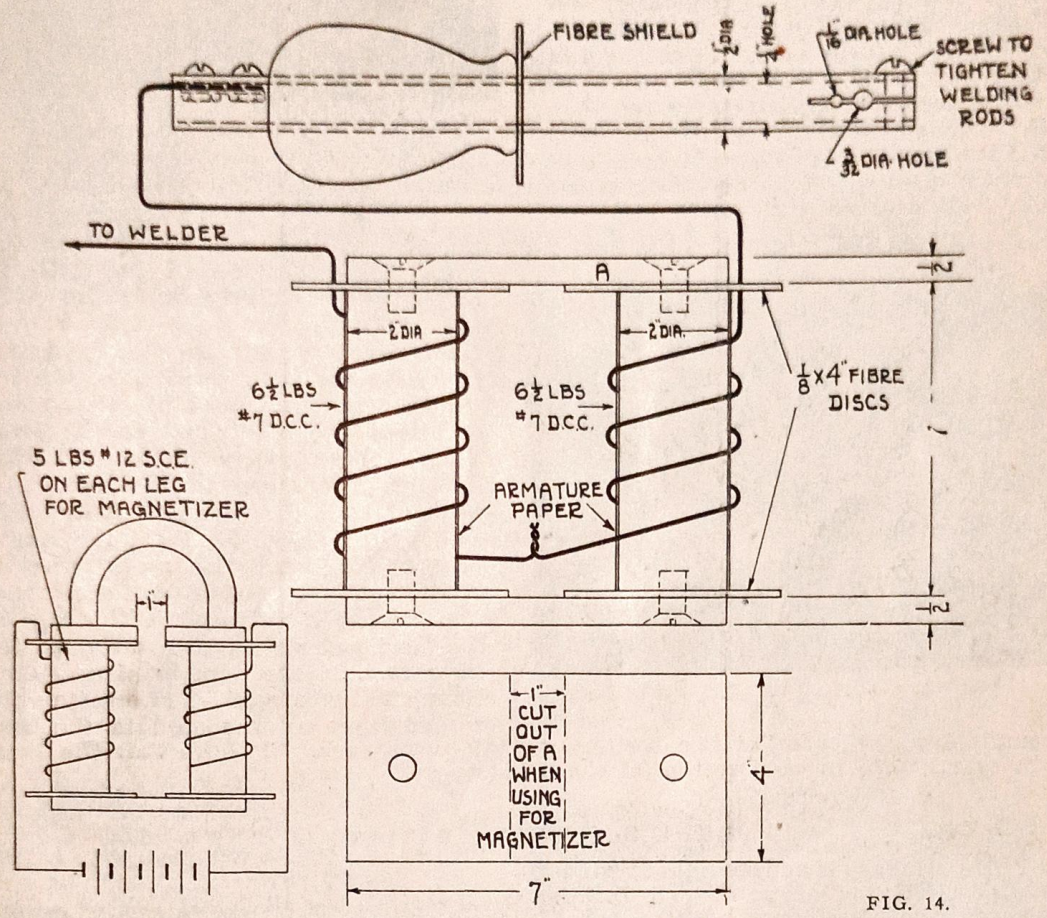


FIG. 14.

REACTOR AND MAGNETIZER

When making up the welder, study carefully Figure 2, page 27, shows how all of the connections are made but the series resistance is not used on small machines. The fields in this drawing are shown as if they were made separately instead of one wound on top of the other. This is done to make the circuits easily understood and is the proper hookup when using one machine.

¶ IV—WELDING TRANSFORMER

A winding form is made from a block of wood $2\frac{11}{16}$"x$2\frac{11}{16}$" long. On one side of the block measure ¾" from the top at one end and ¾" from the bottom at the other end. Draw a diagonal line from these two markings and saw the block in two along this line. After the block has been sawed, clamp it firmly in a vise or clamp and bore a hole through the center large enough to take a mandrel to turn it on.

Cut a piece of .015 insulating paper 7" wide and long enough to make two turns around the form. Wrap a few turns of cotton tape over the paper to hold the paper in place. The beginning of the winding can be held to the core by a small

nail or staple. The primary winding consists of two coils of 125 turns each of number 10 S.C.E. magnet wire. A piece of ¾" cotton tape 24" long is doubled and placed under and over the first turn. It is then woven under and above the first five turns. Wind 20 turns and then pull the tape up and weave it through the remaining five turns. The primary coils are wound in layers of 25 turns each. After the first layer has been wound, cut a piece of .015 insulating paper ¼" wider than the coil and long enough to go around it with about a ½" lap. Place this paper under the first turn of the second layer. Proceed with this layer and the rest of the layers the same as the first one, anchoring the outside turns with cotton tape.

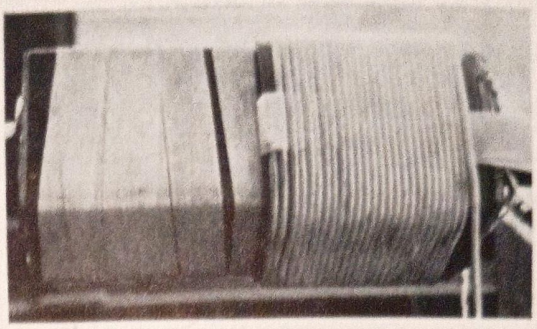


FIG. 1.

When the 125th turn has been reached, which is the end of the first primary coil. Take the roll of tape, double over about 4", place the double under the 125th turn and lap it back over. Hold the tape in place and wrap the roll over it and around the complete winding so it will bind the pieces that hold the wire down to the form. Weave these pieces under and over the layers of tape to hold the wire in place. Cut the wire so that it will be 8" long. See Fig. 2. Start the second layer of the primary letting the wire extend 8" out from the edge of the insulation. Bend it sharply, tie the tape at the bend and wrap the tape around the form to hold the wire in place. Continue the same method of winding the second layer as was used in the first, completing 250 turns in two sections of 125 turns each. Be sure that the turns are exactly 125 in each section of the primary.

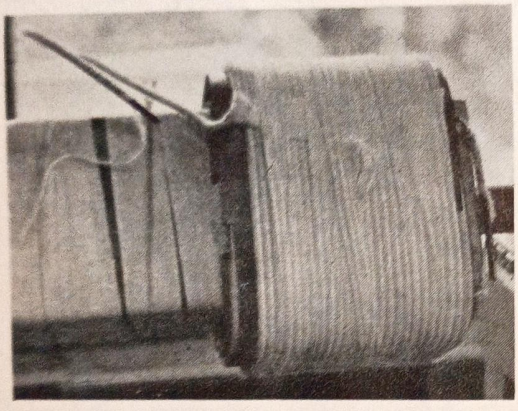


FIG. 2.

THE SECONDARY WINDING

The secondary is one continuous winding of 50 turns of number 5 D.D.C. square wire, five layers of ten turns each. Make a sharp bend 6" from the end of the wire. Lay the wire on the form putting the bend in the center of the form. Make another sharp bend where it will start around the form and tie it to the form with strong cord so that it will be held in place (See Fig. 3). Pound the wire each quarter turn so it will lay square on the forms and lie snugly at the corners. Use the same method in winding the secondary as was used on the primary. Insulate each layer of ten turns with .015 paper and securing the end turns with tape. When the secondary has been wound, slip tubing or sleeving over all of the ends. Then tie them with strong cord so they will not slip out of place. Remove the form from the mandrel and the core from the winding by tapping on the

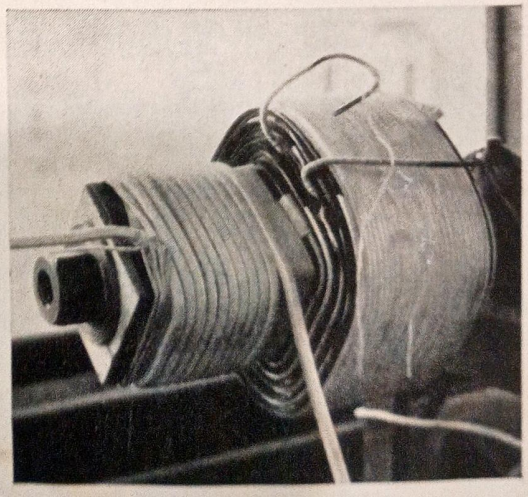


FIG. 3.

small part of the end. After the winding has been removed tape the entire winding length ways. If desired dip in varnish and allow to dry.

ASSEMBLING THE TRANSFORMER

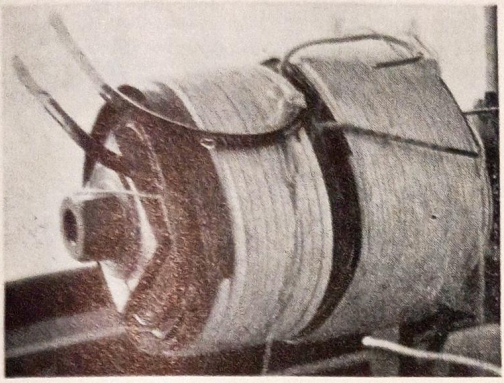


FIG. 4

Cut four pieces of 1" angle iron and bore a ¼" hole in the center ¾" from the top and bottoms. The core consists of 260 pieces of 26 gauge electrical steel (silicon) 2½"x12" and 260 pieces 2½"x 2½". Saw two pieces of two by four pine seven inches long and tack them edge up to the top of the work bench, so that the distance from one outside edge to the other outside edge is 11½". Lay the angle irons on the wood pieces so that the holes will be on top and the other side will extend down on the outside of the pieces of wood. Place 130 pieces of the 2½"x12" steel through the corehole of the winding. Square these laminations up on both sides and place it on the angle irons ¾" from the holes. Then take two stacks of the 2½"x2½" laminations consisting of 130 pieces each and place them up against the ends of the top leg of the core. Another stack of 130 pieces 2½"x12" are laid on the angle irons. The bolts are passed through the other two angle irons and placed on top of the core. Tighten each end up a little at a time and keep the joints of the core butted solid and tight.

Two terminal boards 5" square are made from fibre or bakelite and mounted on each end of the transformer. The ones shown in the illustration are made from ¼" fibre. Mounting holes are drilled in each board ⅝" from the sides and ¾" from the bottom and are held to the angle irons with number 8 machine screws. Terminals 1, 2, 3 and 4 are number 10 brass screws, mounted ¾" from the edges and spaced 3" apart cross ways and 1½" apart up and down.

The first half of the primary winding is connected to terminals 3 and 2. Only this half is used on 110 volts. For 220 or 230 volts connect 1 and 2 together and the line to 3 and 4. The secondary is one continuous winding, it is held to the back terminal board by two ¼" brass machine screws 3" apart, 1½" from the top of the panel, 1" from the sides.

This winding is designed for approximately one turn per volt. If one should happen to have larger wire on hand it could be supplemented for the sizes given but the turns must remain the same. Cross sectional area of the core is 2½"x2½" = 6.25 square inches, if there is iron available 2 inches wide, make the stack 2"x3⅛". Try to keep the core as near square as possible. For 25 or 30 cycle make the iron core 3"x3⅛" in cross section and do not cut the small pieces until you know what size window will be necessary to take the winding. The turns in both the primary and secondary winding will have to be increased 50% for 25 or 30 cycle. Primary winding 360 turns, consisting of two coils of 180 turns each number 10 S.C.E. magnet wire. Secondary winding 75 turns of number 5 D.C.C. square magnet wire.

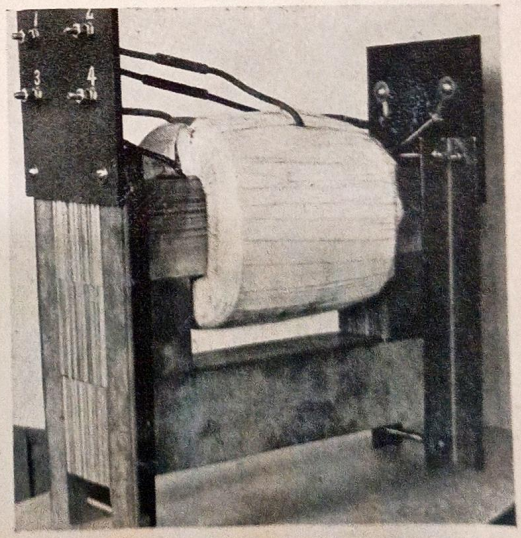


FIG. 5

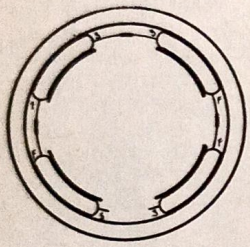
THIS IS A LEAKAGE TYPE TRANSFORMER, it is for this reason that the arc recovers as quickly as it does when welding. Do not try to build it by lap-

ping the joints as the results will not be as good as butting them. Some of the hum can be reduced by using angle iron as wide as the laminations, also by pushing tapered wooden wedges between the winding and steel.

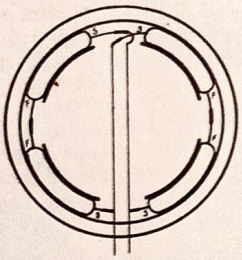
ACCESSORIES

Number four flexible rubber covered wire is large enough for the ground lead and electrode. Two conductor number fourteen cord should be used between the outlet and welder. USE ONLY A.C. RODS WITH THIS MACHINE. It will work rod from $\frac{1}{16}$" to $\frac{3}{16}$". When using the $\frac{1}{16}$" rod connect the transformer for 220 volts and use it on 110 volts. $\frac{1}{16}$" rod draws 20 amps, $\frac{5}{32}$" draws 20 amps, $\frac{1}{8}$" 24 amps, $\frac{3}{16}$" 28 amps, from the line on a 110 volt circuit. On a 220 volt circuit the amperage for the various rods would be half of the 110 volt amperage. CAUTION—always use welding mask, gloves and shirt sleeves down. The rays from this machine are very penetrating and will burn the skin in a few minutes exposure.

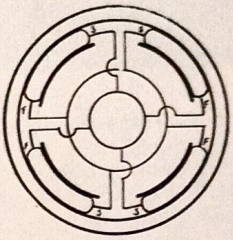
FIELD COIL CONNECTIONS



Series



Two Series Two Multiple



All Multiple

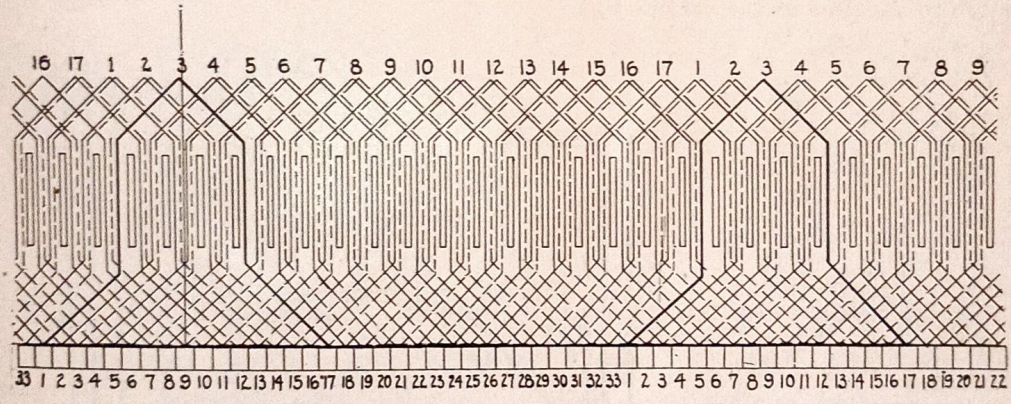
CHAPTER V

¶ 1—AUTOMOBILE ARMATURES

The procedure for rewinding an automobile armature should be carried out the same way as any D.C. armature. By that is meant checking the armature, coil span, winding for the number of turns, and connections at the commutator. These can all be accomplished by the use of a test lamp, and must be done so that the new winding will be exactly like the old one.

In the past few years the majority of automobile generators have been furnished by 2 companies; namely, the Autolite and the Delco-Remy. The winding data for these 2 and 4 pole machine are given. Letters and numbers that are given on an automobile armature designate shaft dimensions and small variations in the armature, but have nothing to do with the winding data.

The Autolite armatures for 4 pole generators, GAA, GAG, GAJ, GAP, GJ, and GP have 17 slots and 33 bar commutators. They are all wound with 2 wires in hand of No. 17 Single Cotton Enamel magnet wire, spanning 5 slots and being connected to bars 1 and 17, or a commutator pitch of 17 bars. See figure 1.



ARMATURE LAYOUT FOR 17 SLOT 4POLE 33 BAR COMMUTATOR AUTOLITE

FIG. 1.

This armature, you will see, with the 17 slots and 33 bars will have 1 coil to be wound in the armature with 1 wire in hand instead of 2. This coil should be put in first as the commutator pitch is more apt to be correct, and the rest of the coils would be merely a following-up of the coil span, turns, and commutator connections.

AUTOLITE armatures for 2 pole generators, GAL, GAM, and GAR, 14 slot armatures with 28 bar commutators, have a coil span of 1 and 7 and are wound with 6 turns of No. 17 Single Cotton Enamel magnet wire, connected lap or to bars 1 and 2 as per figure 2.

All of the 14 slot, 28 bar Delco-Remy armatures are wound with the same coil span and commutator connections as the 2 pole Autolite jobs with the same size of wire, No. 17, 6 turns per coil.

The original winding for the 6 volt Ford generators, model T, is 10 turns of No. 18 S.C.E., coil span 1 and 5 connected to bars 1 and 11. (See schematic diagram in D. C. changes.) The field coils are wound with 6 ounces of No. 19 S.C.E.

The power house type is wound with 6 turns of No. 17 two wires in hand, coil span 1 and 4, commutator connections 1 and 14. (See Fig. 6, page 21.) The field coils are wound with ¼ pound each of No. 18 P.E.

The Ford armatures, No. 10005 and GAU2036, are wound with 6 turns each of No. 17 S.C.E. two wires in hand, coil span 1 and 7 connected to bars 1 and 2. (See Autolite 2 pole lay-out—14 slot 28 bars.) The field coils for the 2-pole Ford generator are wound with ½ pound each of No. 18 P.E. When winding the field coils it is not necessary to count the number of turns but to wind them according to the weight of wire.

Speed is the most essential factor in winding auto armatures. This is necessary for 2 reasons, first to make a profit on the work and second to meet competition. Speed is attained only by practice and convenient methods of doing the work.

To strip the armature place it in the lathe and with a parting tool cut the winding on each side of the lamination. Then with a dull tool drive the winding out of the slots and pull the leads out of the commutator with pliers.

Test the commutator thoroughly for shorts and grounds. If it is necessary to replace the commutator, measure the distance from the end of the shaft and laminations, being sure that the new commutator segments are in the same relative position to the slots as the old one was.

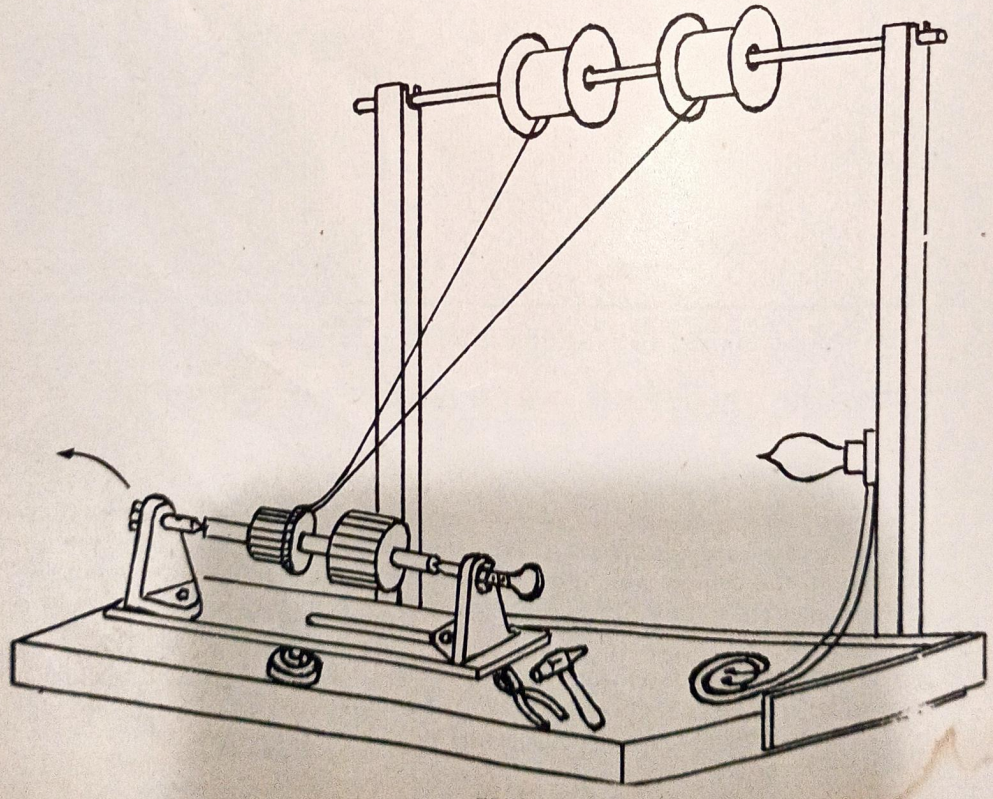


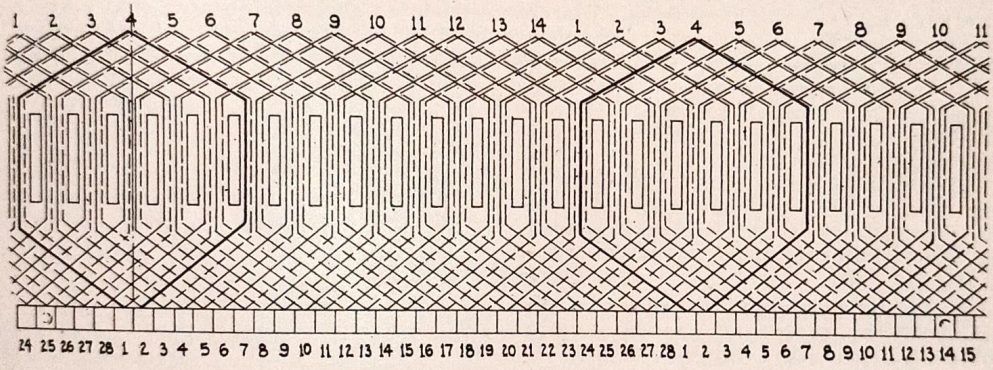
FIG. 3

The armature stand is made so it is adjustable for different lengths of armatures and revolves on the bearing, making it possible for the winder to see each turn

as the wire goes into the slots and the back and front layers. It also keeps the wires from crossing and saves at least one-fourth of the time over any other method of holding the armature.

Reinsulate the armature with new fibre end rings and .010 armature paper. Scrape the 2 wires at one time and drive them with only 1 stroke of the hammer. As most of the armatures are wound with 2 wires in hand it is necessary to keep some kind of mental tab on which wire is first. As the reels of wire are suspended in front of the winder the wire from the left reel is put in the first bar and the wire from the right reel is put in the next bar to the right. After the coil has been placed in the armature slot, cut one of the wires shorter than the other so when the tops of the coils are put down it will be easy to distinguish which one of the 2 tops goes down first.

Most winders do not cut the armature wedges but break the original length (2½ feet) in half and push the wedge into the slot until it is flush with the winding ring and then break it off. After all the coils are down a paper collar is placed over the winding between the commutator and the laminations. The tops are connected to their respective bars. Test the armature before soldering, for if there are any wrong connections or defects in the winding they can easily be located and rectified before the soldering and banding. Assuming that the paper has already been cut flush with the laminations and the armature test has been good, solder and band if necessary and if the price permits this finishing touch. Dip and bake the arma-



ARMATURE LAYOUT FOR 2 POLE 14 SLOT AND 28 BAR COMMUTATOR. DELCO REMY, AUTOLITE AND FORD

FIG. 2.

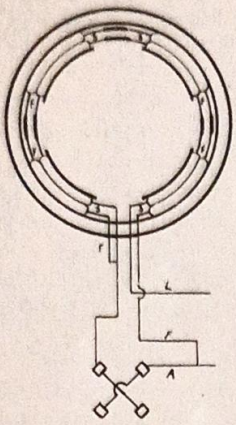
ture and turn the commutator. Three to 8 hour baking varnish is generally used. The clear varnish is most popular as it is more effective—with the customer—as it has more evidence of newness to the eye than black varnish.

Two color wires (one plain white and the other with a tracer) are used by many winders. This eliminates the cutting of the wires different lengths. Generally No. 17½ (.043) is substituted for No. 17. This wire being .002 smaller in diameter than No. 17 leaves more slot room and makes the winding easier.

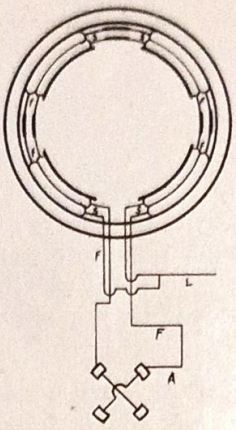
Tests have proved the wire to be superior to the cotton covered both mechanically and electrically. The wire is not made with a tracer. It has slightly more spring to it than the cotton covered wire.

A work bench and its accessories should be arranged as the drawing shows.

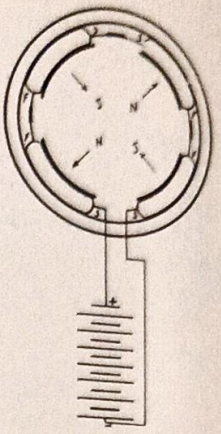
CONNECTIONS FOR FIELD AND POLARITY TEST



Short Shunt Compound Generator



Long Shunt Compound Generator



Polarity test

¶ II—RECONNECTING AUTOMOBILE ARMATURES

Too much emphasis cannot be placed on the necessity of carefully checking all of the mechanical and electrical details of an armature before beginning either the rewinding or reconnecting job. Regardless of the familiarity one may have with any armature these important steps should be taken, for while an armature could be lap or wave connected, the connections at the commutator may have been placed in different positions from the accepted or general practice of connecting the leads to the commutator. Figure 1 shows the usual way for connecting a lap or wave wound armature coil to the commutator. In Figure 1-A the coil is connected to the two commutator bars that are opposite the center of the coil. Figure 1-B illustrates a wave connection. The ends of this coil are connected to the commutator bars that are spaced the same distance apart from the center of the coil.

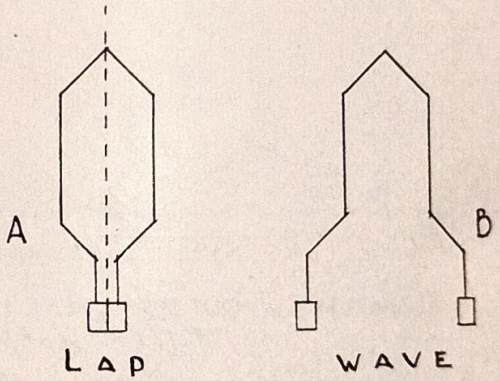


Fig. 1.

Due to some mechanical reason in the design of the motor or generator, the coils of an armature might have to be connected as in Fig. 2-A. This would put the ends of the coil connections out of line from the coil, yet it would still be a lap connection. Notice in Fig. 2-B where the lead of the coil comes straight out from the slot to a commutator bar, the other end of the coil could be placed as far from this connection as the proper commutator pitch would be. Yet this would still be a wave connection.

CHECK CAREFULLY THE NUMBER OF SLOTS AND BARS

There is only one reason for having more commutator bars than slots and that is to reduce the voltage between bars by having a multiple of coils per slot. This in turn improves commutation by eliminating or reducing to a minimum the sparking at the brushes. For an example, if an armature were wound with two coils per slot, two turns per coil, it would have the same voltage as though it were wound one coil per slot, four turns per coil.

To determine the commutator connections, the first thing to do would be to raise the top connections of a couple of coils. Mark each end so that it can be easily identified, and mark each bar the leads were removed from so that there can be no mistake. Then remove the rest of the top leads from the commutator bars. With a test lamp connected to one of the top leads on the first coil raised, move the other

end of the test lamp slowly around the commutator until the lamp lights. This indicates the end of the first coil. Make a sketch of the way the coils lie in the slots and the way they are connected to the commutator. Test several of the coils in this manner to recheck the first one.

GENERAL PRACTICE IN ARMATURE DESIGN

A generator armature winding is usually arranged to give its rated outputs at as low a speed as possible. The logic of this is readily seen since low speed reduces centrifugal strains on the winding, lessens bearing wear, allows the driving force to operate at a lower r.p.m., as well as many other reasons that make it advantageous. Generally the connections at the commutator fit in with this idea, being connected to give the maximum voltage at the lowest speed.

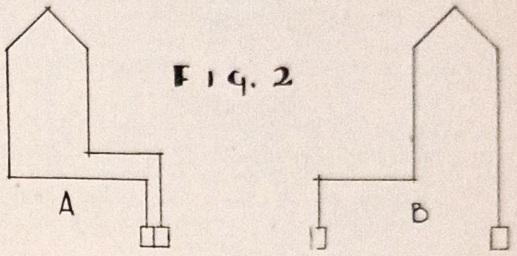


Fig. 2

It is not possible to change the capacity or output of a generator in watts by changing the winding unless there is a speed or mechanical change made. However, it is possible to increase the output in amperage and to lower the voltage by reconnecting the armature.

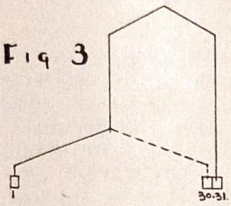


Fig 3

Reconnecting Armature to Increase Amperage. Dotted Line Shows New Connection.

The number of circuits or paths for the current to flow from one brush to another depends entirely upon how the coils are connected to the commutator. When the ends of the coils are connected to bars one and two as in Fig. 1-A, this would be a single circuit lap with two current paths between brushes. By connecting the ends of the coils to bars one and three, the winding is split up into two separate and distinct windings. This gives twice the amperage and one-half the voltage. To get double the amperage and still maintain the original voltage it would be necessary to turn the armature at twice its rated speed. The width of the brush would also have to be increased to cover at least two bars. If the number of bars would allow and the width of the brushes could be increased sufficiently, the number of circuits then could be increased and the amperage raised in proportion. However, there would be a limit as to the speed the armature could be driven. Also commutation difficulties would be sure to arise.

ACTUAL EXAMPLE

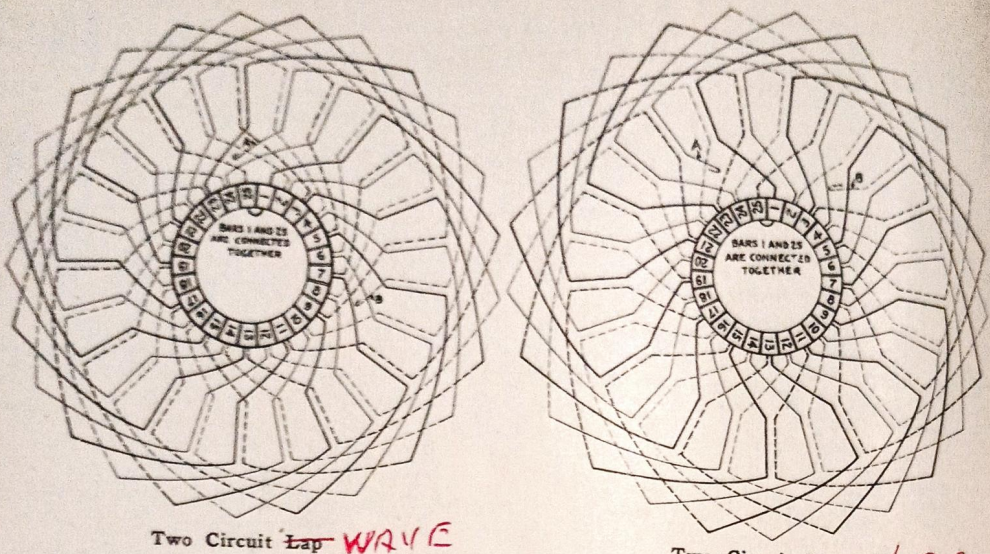
For something definite to work on, take a generator with a 61 slot armature and a 61 bar commutator. Its original winding is a single circuit wave. The commutator connections are to bars 1 and 31. It is good for 70 amps., 40 volts, at 900 r.p.m. However, due to its construction it can be driven safely at 2700 r.p.m. To eliminate work the natural thing to do would be to try to change the winding to a two circuit wave. After tracing the winding out it is found that the next possible change would be to a four circuit wave, which would necessitate two dead coils and two dead bars. However, this would be bound to give commutating trouble, and consequently unsatisfactory results.

By lifting all of the top leads and putting the end of the coil that was in bar one into bar 30 and moving the rest of the bottom leads over so they will follow up in their respective positions, and then replacing the top leads in the bars they were removed from, the winding can be changed to a single circuit lap winding. This would increase the amperage output to 140 amps, 40 volts at 1800 r.p.m. See Fig. 3.

This would be the most likely change for the winding. The amperage could be increased further by the addition of a series winding. If the generator were intended for welder service, it would be best to separately excite the fields and use the series winding to buck the shunt.

In experimenting with this generator five turns per coil of two number six lead wires were wound around each field coil. The reason for using them was because they would not have to be insulated any more than the original covering and would take up the least amount of space. They could be wrapped around the outside of the coils very readily.

There are many changes that can be made by reconnecting armatures. Before attempting any of them be sure that they work out on paper first. Figure 4



Two Circuit ~~Lap~~ WAVE

Two Circuit ~~Wave~~ LAP

FIG. 4. Layout of 25 Slot, 25 Bar Armature Connections.

shows a 25 slot 25 bar armature connected for two circuit lap, and two circuit wave. Notice the two separate circuits that have no connection with each other. Both of these connections would be impractical, due to the small number of bars in the commutator, and the drawing is shown only to give the idea of the separate circuits in the armature and to show the possibilities in reconnecting. An ideal condition would be when a reconnection leaves no dead coils or commutator bars. But when a commutator has a great number of bars, satisfactory results can be obtained by connecting bars together and leaving a dead coil.

When rewinding armatures for a lower speed, the number of turns per coil should be increased in proportion to the decrease in speed desired. This would also mean that the size of wire would be decreased and the output of the generator would decrease in proportion to the speed.

CHAPTER VI

WIND POWER PLAN HEAD MOUNTING

A Model T Ford differential housing forms the backbone of this construction. With a hack saw cutoff the axle housing on one side two inches into the flange. See Fig. 1. Into this shortened end weld a front wheel spindle taken from a Model T. Be sure the spindle is lined up perfectly at right angles to the differential case, because it is to become the axis for the propeller.

Now, reversing the differential, cut off the shaft housing at D in the drawing, leaving two inches of the axle shaft housing projecting. After squaring the new end, fill the opening with babbitt, several inches deep. Then drill a $\frac{7}{16}$" hole vertically through the housing and babbitt to take care of the tail vane mounting. This mounting consists of two U-type brackets welded together. These may be made

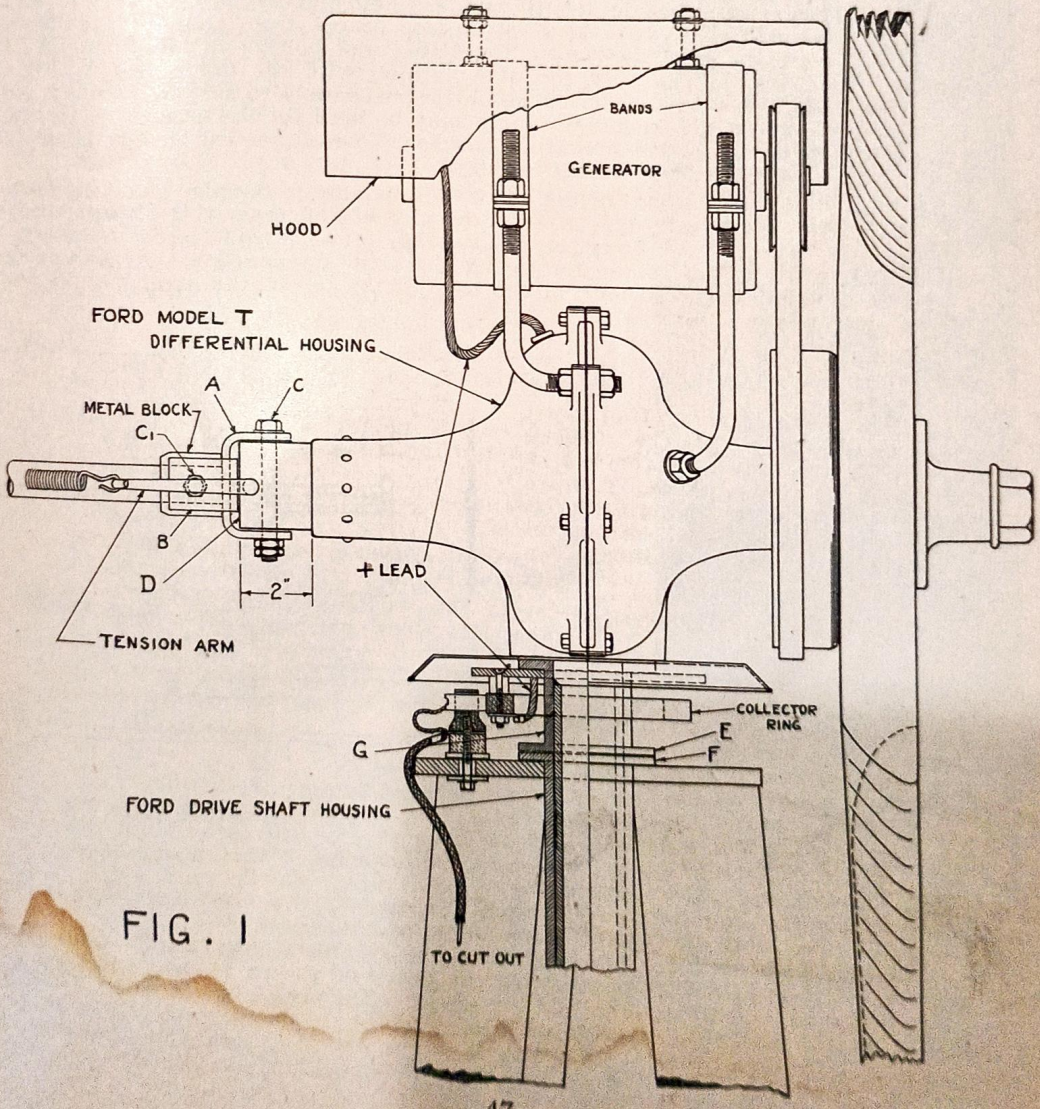


FIG. 1

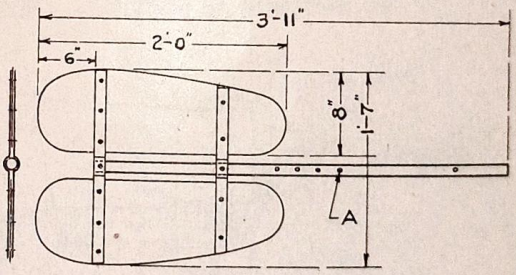
of two flat pieces of heavy 2″ strap iron by heating and pressing into the desired shape. Both U pieces should be 2″ deep and 2⅜″ long inside. Drill a $\frac{7}{16}$″ hole (C) at the tip of each side of U piece (A), so that the holes on each side are in line with the hole in the housing. Take a piece of metal large enough to make a snug fit for the ¾″ tail vane pipe and mount it in the outer U-bracket (B). After the pipe has been inserted so that the end fits flush with the back of the bracket, drill a $\frac{7}{16}$″ (C-1) hole through the whole assembly, and through this, bolt the vane arm securely. The metal piece will keep the vane from sagging. Before mounting the head round off a small portion of the axle housing and babbitt on the side toward which the tail vane will turn when being pulled out of the wind. Leaving the other side squared off, it will act as a stop when the tension spring pulls the vane back into running position. Also at this point thread a horizontal arm into the end of the axle housing to form the tension spring hanger. Now bolt the linked brackets to the axle shaft through the $\frac{7}{16}$″ hole (C) previously drilled. Be sure that the inner bracket has room enough to pass freely across the rounded side of the shaft end.

MAKING THE VANES

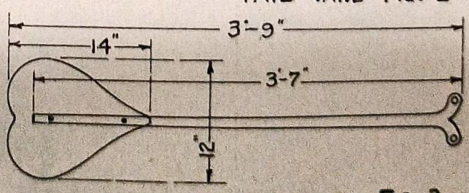
The vane consists of a piece of ¾″ pipe 3′ 5″ in length, two tail pieces cut from old auto body iron, or some such material, and mounted on the length of pipe by a pair of strap iron braces on each side of the vanes. See Fig. 2. The tail pieces are cut oval shape, two feet in length and spreading at the widest part to eight inches. Both ovals are riveted to the 1″ strap iron braces, front and back, the braces having a ¾″ offset in the mid-section for fitting and bolting to the center of the vane arm. Drill several holes in the pipe parallel with the brace fitting. Fig. 2 at A. These make the tension spring mounting adjustable to several tensions. Any sturdy spring about twenty inches in length may be used for the tension device, just so it pulls the vane back into operating position. The other end is hooked to the arm already mounted in the axle shaft housing.

For pulling the vane out of the wind, bolt a clamp to the pipe about six inches out from the bracket mounting. A rope or wire is run from this clamp through the differential housing and down to the ground. If it is considered necessary, a pulley arrangement may be made for easing the shut-off operation. By pulling the wire and holding it taut in a hook at the base of the tower, the plant may be kept out of running position.

To furnish further means of control, a stationary vane is mounted at right angles to the propeller. See Fig. 3. Cut another piece of sheet iron heart shape—twelve inches at the deepest flange and fourteen inches from tip to back. Rivet this to a Model T brace rod cut 3′ 7″ in length. Using the original fork of the rod, bolt the control vane to the differential housing. Tap out $\frac{7}{16}$″ holes to suit for the mounting.



TAIL VANE FIG. 2



CONTROL VANE FIG. 3.

Sketches of Vane Construction

ANCHORING GENERATORS

Since a direct drive is not being used, the generator is placed over the differential head and held firmly by top and belly straps made out of 1″ steel bands. The ends of the straps are set in four $\frac{7}{16}$″ steel rods tapped into the head and threaded deep enough at the tops to enable lowering or raising the generator. This will give complete adjustment to the belt from the drive pulley.

A hood fashioned of sheet metal is made to protect the generator. It is held in place by two stud bolts tapped into the generator 1½″ high in order to give ample cooling space.

The propeller used on this head is of the two-blade type, cut from a single piece of 2″x6″x7′ fir lumber. In selecting the board be sure it is solid and true, because it will have to withstand a wide range of wind pressure. It is also well to keep in mind the principle of all wind power propeller construction. That is, the blades must be so built that the velocity is taken out of the wind in the form of power. This is done through degree of pitch grooved into the blade.

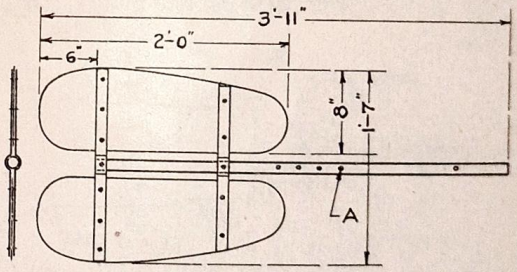
of two flat pieces of heavy 2" strap iron by heating and pressing into the desired shape. Both U pieces should be 2" deep and 2⅜" long inside. Drill a 7/16" hole (C) at the tip of each side of U piece (A), so that the holes on each side are in line with the hole in the housing. Take a piece of metal large enough to make a snug fit for the ¾" tail vane pipe and mount it in the outer U-bracket (B). After the pipe has been inserted so that the end fits flush with the back of the bracket, drill a 7/16" (C-1) hole through the whole assembly, and through this, bolt the vane arm securely. The metal piece will keep the vane from sagging. Before mounting the head round off a small portion of the axle housing and babbitt on the side toward which the tail vane will turn when being pulled out of the wind. Leaving the other side squared off, it will act as a stop when the tension spring pulls the vane back into running position. Also at this point thread a horizontal arm into the end of the axle housing to form the tension spring hanger. Now bolt the linked brackets to the axle shaft through the 7/16" hole (C) previously drilled. Be sure that the inner bracket has room enough to pass freely across the rounded side of the shaft end.

MAKING THE VANES

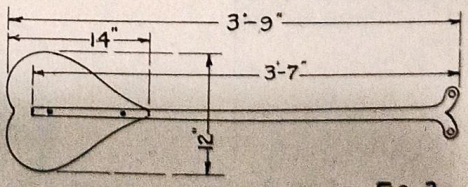
The vane consists of a piece of ¾" pipe 3' 5" in length, two tail pieces cut from old auto body iron, or some such material, and mounted on the length of pipe by a pair of strap iron braces on each side of the vanes. See Fig. 2. The tail pieces are cut oval shape, two feet in length and spreading at the widest part to eight inches. Both ovals are riveted to the 1" strap iron braces, front and back, the braces having a ¾" offset in the mid-section for fitting and bolting to the center of the vane arm. Drill several holes in the pipe parallel with the brace fitting. Fig. 2 at A. These make the tension spring mounting adjustable to several tensions. Any sturdy spring about twenty inches in length may be used for the tension device, just so it pulls the vane back into operating position. The other end is hooked to the arm already mounted in the axle shaft housing.

For pulling the vane out of the wind, bolt a clamp to the pipe about six inches out from the bracket mounting. A rope or wire is run from this clamp through the differential housing and down to the ground. If it is considered necessary, a pulley arrangement may be made for easing the shut-off operation. By pulling the wire and holding it taut in a hook at the base of the tower, the plant may be kept out of running position.

To furnish further means of control, a stationary vane is mounted at right angles to the propeller. See Fig. 3. Cut another piece of sheet iron heart shape—twelve inches at the deepest flange and fourteen inches from tip to back. Rivet this to a Model T brace rod cut 3' 7" in length. Using the original fork of the rod, bolt the control vane to the differential housing. Tap out 7/16" holes to suit for the mounting.



TAIL VANE FIG. 2



CONTROL VANE FIG. 3.

Sketches of Vane Construction

ANCHORING GENERATORS

Since a direct drive is not being used, the generator is placed over the differential head and held firmly by top and belly straps made out of 1" steel bands. The ends of the straps are set in four 7/16" steel rods tapped into the head and threaded deep enough at the tops to enable lowering or raising the generator. This will give complete adjustment to the belt from the drive pulley.

A hood fashioned of sheet metal is made to protect the generator. It is held in place by two stud bolts tapped into the generator 1½" high in order to give ample cooling space.

The propeller used on this head is of the two-blade type, cut from a single piece of 2"x6"x7' fir lumber. In selecting the board be sure it is solid and true, because it will have to withstand a wide range of wind pressure. It is also well to keep in mind the principle of all wind power propeller construction. That is, the blades must be so built that the velocity is taken out of the wind in the form of power. This is done through degree of pitch grooved into the blade.

NOTES ON WIND VELOCITIES

That air current, or wind, is always moving more rapidly in the upper layers of atmosphere is evidenced by a recent report issued by the U. S. Weather Bureau in which observations were recorded from elevations of 103 feet and 306 feet. At 103 feet in only one hour out of eight does the wind reach a velocity of over 10 miles per hour. At 306 feet the wind blows at more than ten miles per hour for one half the year, or every other hour when expressed in averages. From this it may be assumed that the lower the elevation, the more hours the wind blows under ten miles per hour.

This factor should be taken into consideration when building a wind power plant tower. It must be kept in mind that the real power to be taken from the wind must be taken from a velocity of ten miles per hour or lower. This in turn explains the necessity of using a generator wound for slow speed generation.

It is also well to keep in mind the prevailing wind for the locality in which the tower is being erected or head placed.

Following are some handy means of estimating wind velocity.

ESTIMATING WIND VELOCITY

Miles	Specifications of Wind Force
less than 1	Calm; smoke rises vertically.
1–3	Direction of wind shown by smoke drift, but not by wind vanes. Just moves leaves, not branches.
4–7	Wind felt on face; leaves rustle; ordinary vane moved by wind.
8–12	Leaves and small twigs in constant motion; wind extends small flag.
13–18	Raises dust and loose paper; small branches are moved.
19–24	Small trees in leaf begin to sway; crested wavelets on inland waters.
25–31	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
32–38	Whole trees in motion; inconvenience felt in walking against wind; raises clouds of dust.
39–46	Breaks twigs off trees; generally impedes progress.
47–54	Slight damage occurs (chimney pots and slate removed); hinders walking.
55–63	Seldom experienced inland; trees uprooted; considerable structural damage occurs.
64–75	Very rarely experienced; accompanied by widespread damage.
above 75	Hurricane.

Plant Assembled, Ready to Produce Power

TOWER MOUNTING

To mount the assembled head to the tower, there must be a turn table. G in Fig. 1 shows the Ford spool that goes between the drive shaft housing and the differential. This spool and the face of the drive shaft housing are case hardened and make a perfect turn table. The holes at E and F are filled with babbitt and ground down to a smooth finish. Weld the spool to a 1½" pipe which, when inserted into the drive shaft housing will fit perfectly. The upper portion of the spool is bolted to the differential case. An inverted 10" pie tin mounted at this connection will make a good water shed for the brush assembly. A piece of ⅛" bakelite mounted to the upper flange of the spool forms the insulator upon which the brass collector ring is attached.

For the lower half of the turn table, cut off the drive shaft housing where the taper starts. To this point weld a spreader from an old windmill. This enables mounting the table to the tower.

NOTES ON WIND VELOCITIES

That air current, or wind, is always moving more rapidly in the upper layers of atmosphere is evidenced by a recent report issued by the U. S. Weather Bureau in which observations were recorded from elevations of 103 feet and 306 feet. At 103 feet in only one hour out of eight does the wind reach a velocity of over 10 miles per hour. At 306 feet the wind blows at more than ten miles per hour for one half the year, or every other hour when expressed in averages. From this it may be assumed that the lower the elevation, the more hours the wind blows under ten miles per hour.

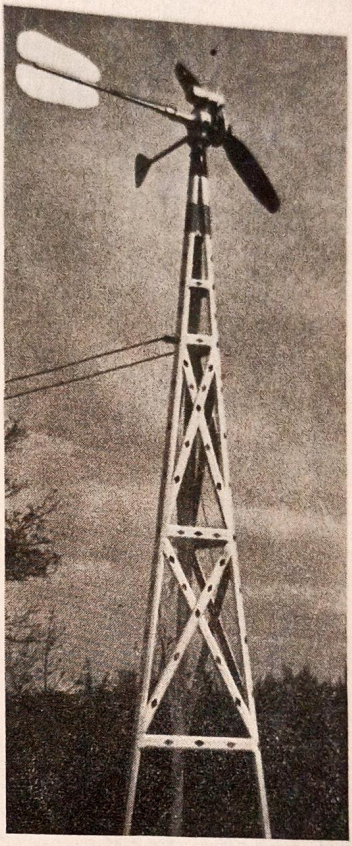
This factor should be taken into consideration when building a wind power plant tower. It must be kept in mind that the real power to be taken from the wind must be taken from a velocity of ten miles per hour or lower. This in turn explains the necessity of using a generator wound for slow speed generation.

It is also well to keep in mind the prevailing wind for the locality in which the tower is being erected or head placed.

Following are some handy means of estimating wind velocity.

ESTIMATING WIND VELOCITY

Miles	Specifications of Wind Force
less than 1	Calm; smoke rises vertically.
1–3	Direction of wind shown by smoke drift, but not by wind vanes. Just moves leaves, not branches.
4–7	Wind felt on face; leaves rustle; ordinary vane moved by wind.
8–12	Leaves and small twigs in constant motion; wind extends small flag.
13–18	Raises dust and loose paper; small branches are moved.
19–24	Small trees in leaf begin to sway; crested wavelets on inland waters.
25–31	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
32–38	Whole trees in motion; inconvenience felt in walking against wind; raises clouds of dust.
39–46	Breaks twigs off trees; generally impedes progress.
47–54	Slight damage occurs (chimney pots and slate removed); hinders walking.
55–63	Seldom experienced inland; trees uprooted; considerable structural damage occurs.
64–75	Very rarely experienced; accompanied by widespread damage.
above 75	Hurricane.



Plant Assembled, Ready to Produce Power

TOWER MOUNTING

To mount the assembled head to the tower, there must be a turn table, G in Fig. 1 shows the Ford spool that goes between the drive shaft housing and the differential. This spool and the face of the drive shaft housing are case hardened and make a perfect turn table. The holes at E and F are filled with babbitt and ground down to a smooth finish. Weld the spool to a 1½" pipe which, when inserted into the drive shaft housing will fit perfectly. The upper portion of the spool is bolted to the differential case. An inverted 10" pie tin mounted at this connection will make a good water shed for the brush assembly. A piece of ⅛" bakelite mounted to the upper flange of the spool forms the insulator upon which the brass collector ring is attached.

For the lower half of the turn table, cut off the drive shaft housing where the taper starts. To this point weld a spreader from an old windmill. This enables mounting the table to the tower.

The positive lead from the generator passes through the grease plug hole in the differential housing and connects to the collector ring. The current is carried off of the collector ring through the stationary brush to the cutout. The negative side of the generator is carried to the battery through the frame of the generator, the housing, and the turntable pipe. The wiring arrangement can be made to suit the individual's idea and fit in with whatever original ideas one may wish to incorporate in the design.

View of Generator Drive

GENERATOR

This is also true of the type of generator to be used, but for efficient operation it should have a low speed winding. The one used on this plant is a Dodge generator rewound for 32 volts to have a cut-in speed of 350 r.p.m. The armature is wound with 20 turns per coil of No. 17 cotton enamel, using the original coil span and commutator connections. The fields are wound with 1½ pounds each of No. 21 plain enamel and are connected to the two stationary brushes.

By using a three to one drive ratio the blades need turn little over 100 r.p.m. before current is generated. In a good wind the plant has an output of 18 to 20 amperes at 32 volts.

The tower for this head shown in the illustration is made from 2″ x 4″ lumber, a three post design, with all brace pieces mortised. All edges are beveled. The tower is coated with white enamel, with the bands close to the head and the diamonds in red and blue. Aluminum paint is used on the head.

BEVELING THE PROPELLER

The sketches shown are of the blade in various stages of construction. Refer to Figure 4-a after the board has been selected and the exact center located. Six inches on each side of center mark a line. See B in sketch. Then draw a line one inch up from the bottom on each end, at A. Now from A to B on each edge draw a diagonal line. The board should now appear as in Figure 4-a, the ruled off section on the board being the shaded part in the drawing. Cut away all of the shaded section. When finished, the stick will be one inch thick at the ends, tapering to full thickness six inches from the center. This forms the back side of the propeller.

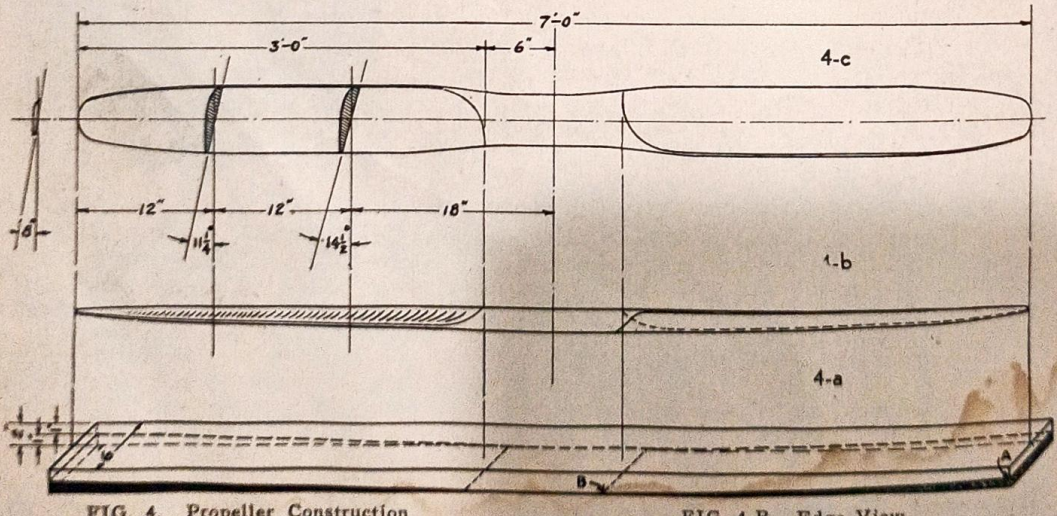


FIG. 4. Propeller Construction
FIG. 4-A. Ruling the Board

FIG. 4-B. Edge View
FIG. 4-C. Full Face View

Now turn the board over and prepare to bevel the face. Figure 4-b is an edge view showing the section cut away on the back, with curves indicating the development of the bevel on the face. Figure 4-c is a full face view of the propeller, with cut-in cross sections indicating the degree of pitch, at various distances from the center, to be grooved into the blade. It will be noticed that the greatest pitch is nearest the hub of the blade. There it reaches seventeen degrees. Working out toward the tip, the blade is left almost flat, or as shown in the drawing, with an eight degree bevel. The result will be a trailing edge ⅛" thick and a rounded leading edge of almost the original thickness.

Again turn the blade over and round the edges a little, and taper the ends, starting about ten inches back, to a width of three inches. Also cut down the mid-section to a 4½" width, to fit the Ford wheel hub. Balance the blade on a knife edge; shaving from the back side of the blade in order to perfect the balance.

When balanced drill the center to fit the Model T front wheel hub. Also drill holes to suit mounting of hub plate.

With a fine sandpaper, rub the blade to a smooth finish. Then waterproof with a coat, or coats, of shellac or varnish. When the coating is dry, mount the Ford hub plate to the front side of the propeller hub. On the back, center and bolt a Model T Ford brake drum or a 9" V pulley to serve as the drive pulley. Then mount the propeller to the spindle previously welded to the differential case, using the original Ford hub nut and hub cap.

The head is now finished.

CHAPTER VII

WATER WHEEL DRIVES

To make an estimate of what any particular stream will deliver, select a section of the stream which is adaptable for such a test. This means a dam site that will allow a pond to form about one and one-half times the width of the opening to be made in the dam. Also the fall to the water level below the dam should not be less than eight inches. The width of the opening should be about four times the depth of the water which will flow over the crest.

When the site has been selected, construct a weir, which is a sharp-crested dam, so built that the water will flow over it freely. Ordinarily this type of dam is made with a board in which a notch has been cut, see Figure 1, with both edges and bottom sloped to the down stream side. In estimating the flow of a small stream where the depth of the flow is not more than a foot make the notch four feet wide; increasing this dimension in proportion to the depth of the flow when measuring larger streams. The bottom of this notch, or crest, should be level and the sides vertical. At a distance of not less than the width of the notch in the dam drive a stake into the stream bed so that the top of the stake is even with the crest of the dam. When the full flow is passing over the dam, a gauge or ruler held to the top of the stake will give the depth of the flow.

FIG. 1. View Showing Method of Measurement

Pace off distances of fifty and one hundred feet up stream from the weir. From these distances send a float down the stream and over the dam, timing the speed of the float. The float may be any of a number of objects, but should be heavy enough to sink well into the water. A float resting merely on the surface of the stream would not give a fair test of the underflow. By timing the speed of the float from both distances and taking an average, a fairly accurate rate may be had of the stream velocity in feet per second.

Multiply the depth of the flow by the width of the weir notch by the rate of flow per second will give the volume of the stream in cubic feet per second. For example: If the width of the opening in the dam is four feet, the depth of the flow one foot, and the rate of flow is found to be eight feet per second, the volume of flow will be 4 ft. $\times$ 1 ft. $\times$ 8 ft. per sec. = 32 cubic feet of water per second.

CONSTRUCTION OF OVERSHOT WATER WHEEL

Where there is considerable volume of water flowing down a stream, but the possible head, or fall, is only six feet, or thereabouts, an overshot wheel will prove the most effective. Following are the construction details for such a wheel, designed for the most part to make use of junk materials.

Two rake wheels about 56" in diameter, each having a sturdy hub, form the skeleton foundation. See Figure 2. Tap the hubs for ½" set screws. Fit the wheels to a 1¼", or larger, auto truck drive shaft, placing them far enough apart so that the ends of the buckets will be flush with the outside rim when they are mounted later. This distance will vary with the size of buckets used; usually about 28 inches. The shaft should be fitted to the hub; the hubs being tapped for ½" set screws, set into the shaft ¼" after the wheels are properly spaced.

The wheel should be covered with three inch tongue and grooved flooring ¾" thick, each board being cut the same length as the buckets, which will be described further along. A ¼" hole is bored through the rim of the wheel at the location of each board. Using ¼" bolts securely fasten the flooring to the wheel rims. Be sure to start the first board square with each wheel, and remember to check occasionally, as this even placing is an important factor toward having a smoothly running water wheel.

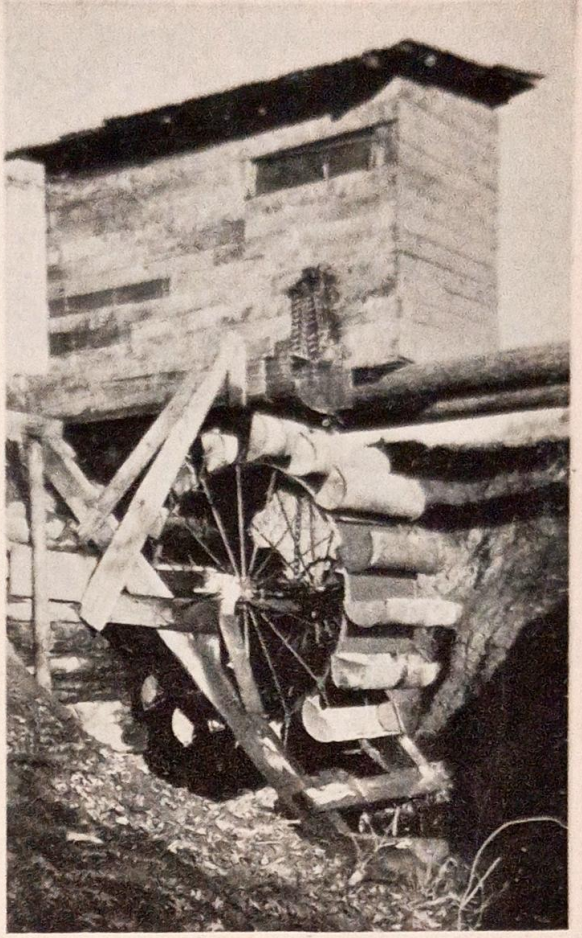


FIG. 2—Overshot Wheel Mounted and Ready to Take the Water.

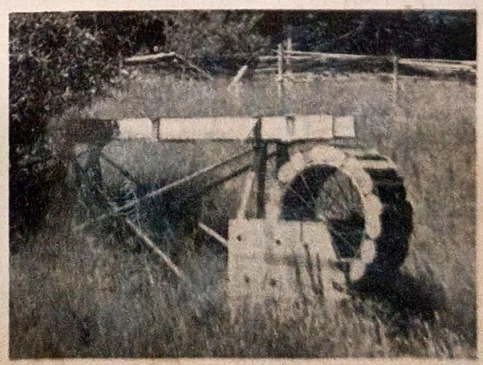
A STURDY FOUNDATION IS IMPORTANT

It is a good plan at this point to have the shaft set, secured in place and a foundation built of concrete. If costs must be watched, a base of heavy timbers, mortised and well braced, will do. However, do not overlook the foundation and wheel pit, as two tons of water or more will pour over the wheel every minute; therefore the need for sturdy construction at this point. If concrete is being used, make the side walls of the pit at least 8" thick, and allow the wheel a ten inch clearance from the runoff water. The wheel should now be mounted in heavy iron babbitted boxings. A more satisfactory mounting is a roller bearing fitted from an old car, even though it may be necessary to have the shaft turned down in a lathe in order to make the desired fit. To keep the wheel from sliding sidewise, use set collars inside at each bearing.

The buckets are made from Model T Ford gas tanks, oval type, cut lengthwise with a cold chisel, so that each tank will make two buckets. See Figure 3-A. These tanks may be secured from a junk dealer who usually has tanks that are unfit for their original purpose, but make efficient water wheel buckets. It will take eight tanks to give the 16 buckets needed.

MOUNTING THE BUCKETS

When the buckets are ready for installation, divide the wheel into 16 equal spaces. See Figure 3. Under no consideration should the buckets be placed closer than 13" tip to tip. If the diameter of the wheel is greater than 56", another bucket should be added and the space kept at 13 inches. Fasten each bucket square across the wheel with four ¼" carriage bolts, placing washers on the back next to the wood. Set the buckets with the tip edge slightly in advance in order to make sure that



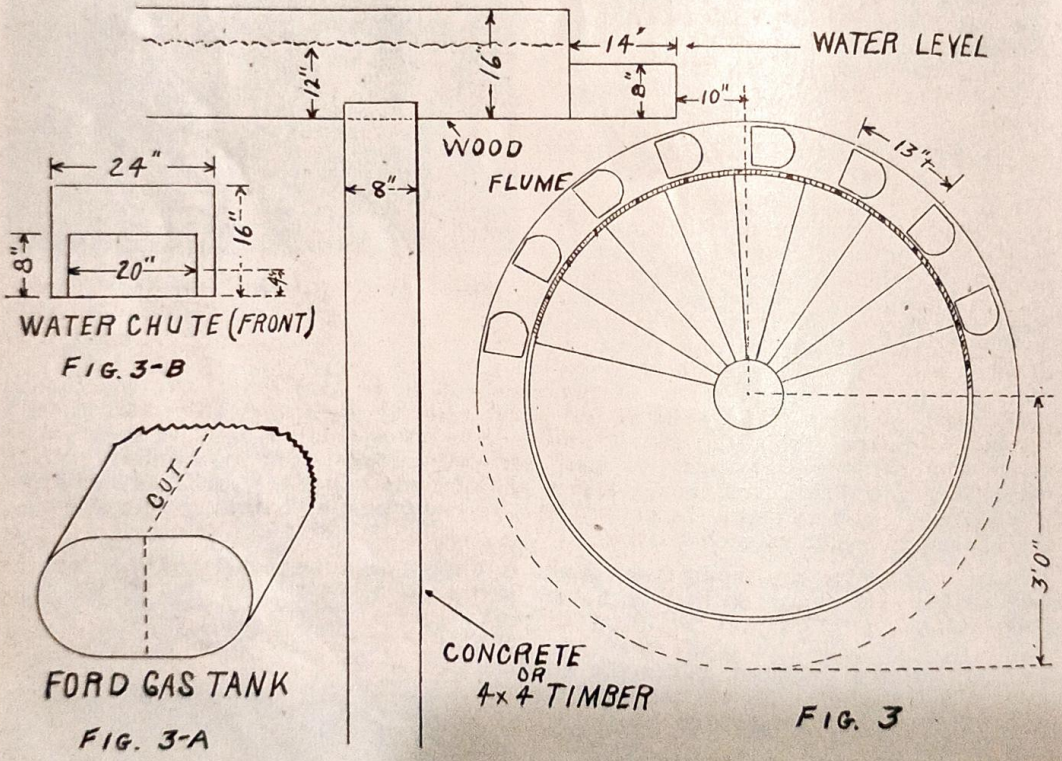
Another Overshot Wheel

they will dump completely by the time dead bottom is reached. A little experimenting with a bucket filled with water will give one the idea as to proper setting.

Enclose the ends of the buckets with curved segments of sheet iron, which may be auto body iron or some similar material, each segment cut to the radius of the wheel and wide enough to cover the ends and wood flooring. Rivet these with tinners' rivets to the bucket, using small galvanized nails in the ends of flooring.

To bring the water to the wheel use a ditch or a concrete lined flume, graded to a fall of three inches per 100 feet. See Figure 3-B. Deliver to the wheel proper from a 24" wide by 16" high wooden flume. The delivery end should form a tank with a water chute 14" long by 20" wide by 8" high, having a 4" by 20" water opening in the end next to the flume. This chute is to give the water the velocity of the wheel rim and should clear the rim by one inch, and be placed back from the center line of the wheel ten inches. The flume back of the wheel may be mounted on a concrete wall or heavy timbers. A gate and trash rack should be provided where the water enters the flume.

While there is a certain amount of latitude in the mounting of this wheel, the chief construction points must be closely adhered to in order to gain a maximum result. It has proven to be very efficient and will handle from 60 to 100 cubic feet of water per minute and deliver about 5 h.p. on a 6′ head and from 25 to 30 r.p.m.



Sketches Showing Placements of Buckets, Structure of Foundation and Water Chute, and How Buckets Are Made.

AN IMPULSE WATER WHEEL

Where the volume of water flowing down a stream bed is not great enough to accommodate an overshot wheel, but a fall of at least eight feet can be had, an

impulse wheel, or open turbine type, may be used to good advantage. One cubic foot of water per second dropped down a pipe eleven feet long will generate one horse power. The more the fall, or head, the less water will be needed and the more power will be generated. So, when making this type of wheel, keep in mind to take advantage of every possible foot of fall. See Figure 4.

FIG 4. An Impulse Wheel Powered by the Flow From Three Nozzles

For this job use one-half of a Model T Ford rear end, including axle shaft and bearings. First cut the bell part off clean, so the shaft sticks through. This is important, because later a pulley is to be attached to it. The best and easiest way to remove the bell is to burn it off with a torch. However, if the torch is not available, the work can be done with hack saw and chisel. Now obtain a Ford rear wheel with the brake band removed. Key and lock-nut this wheel to the shaft on the end farthest from the bell part.

CUP-LIKE BUCKETS ARE FORMED

Make 19 buckets 2¾" in width by 1" deep, rounded cup-like as shown in the illustration. For this purpose old auto body iron is very serviceable. In shaping the buckets either of these two ways will do the job nicely: using a die turned out in a lathe, or forming the buckets by hand over a hard wood block or babbitt metal pattern. Now remove the solid one-piece demountable rim from the rear wheel and mount the buckets, brazing them on if possible, if not, riveting will do, 4½" apart, tip to tip. See Figure 5. Replace the rim, and, providing the shaft and rear wheel have been firmly set in a good foundation and housing at the base of the fall, the impulse wheel is now ready to take the water.

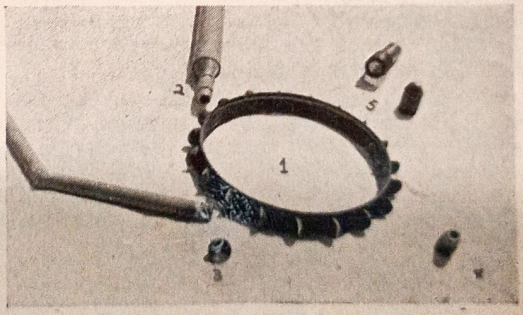


FIG. 5. No. 1 Shows How Buckets Are Mounted on Demountable Rim. No. 2. The Relation of Nozzle to Bucket. No. 3. A Formed Bucket. No. 4. A Nozzle. No. 5. Die for Forming Buckets.

The water from the head is shot against the buckets from nozzles at the base of pipes leading from the top of the fall. In making these nozzles take a 1½" galvanized pipe coupling and fit a piece of tin in the form of a collar around one end and extending 1½" past the coupling proper. A tapered core may be placed in the center of the coupling, or it may be cast solid and bored out later in a lathe. The old type hard wood telephone insulator bracket is just about right for this form. Stop up the other end with a wooden plug or putty to save about ½" of the pipe thread. The material for pouring may be babbitt, but ordinary battery lead will give plenty of service. After this is cast and cooled, remove the plug, collar, and form, and chuck in a lathe and turn a smooth inside taper from the threads to an opening about 1¼" at the other end. Then taper the outside to about ½" thick at the discharge end. The size of the hole will of course depend on the head of water. Using two of the above nozzles on an 8' head, the water capacity will be about 60 cubic feet per minute. Remember, the higher the head, the smaller the opening in the nozzle.

MOUNTING THE NOZZLES

Mount each nozzle on a 4" galvanized down spout pipe, using a piece of galvanized iron made funnel shape as the connection. Make these connections secure by soldering. Now mount the nozzles firmly into a position so that they just clear the buckets and remain in perfect alignment with the bucket centers. More than one nozzle may be mounted to a wheel, and every one mounted doubles the power as long as the water lines do not conflict with one another.

For low heads a wooden flume 24" wide and 16" high with discharge end closed to form a tank can be used. A flume such as this must of course be run high enough above the wheel to give the full head. The nozzle lead pipes extend from holes in the bottom of the flume to the wheel. Where it is possible to have a higher head, it is necessary to pipe the full head to the wheel. Consequently more power is obtained.

While this type of wheel is not as efficient on low heads as is the overshot, on heads over 20' such a wheel will give excellent service. On the low heads of 8' this wheel should develop ½ to ¾ h.p. at 150 r.p.m. A V-type pulley keyed to the bell end of the shaft and hooked to a slow speed generator will give a very quiet and dependable home generator plant.

SELECTION OF GENERATOR

Since the generator is the real heart of such an installation, selection of the generator demands careful consideration. Five years of experimental work has led to the conclusion that most faulty plants would be made successful if the generator was fitted to the job. One can imagine the high pulley stepping up it takes to get 2000 r.p.m. on a generator shaft from a water wheel of 25 to 30 r.p.m. The solution finally came through the use of the slow speed generator, specifications for which is given in Autopower. Thus it is possible to build a generator that will cut in at 500 r.p.m. or less.

In one overshot water wheel plant a Model G. Dodge generator rewound to lower r.p.m. specifications. Eighteen turns of No. 20 S.C.E. wire was used in each armature coil, and one pound of No. 24 S.C.E. wire per field coil. At 840 r.p.m. this generator delivered 5 amperes at 40 volts. With the use of storage batteries in the plant this will prove sufficient. With this type of generator, by the use of V-belts in one or two steps, and a few auto batteries you will have a plant to show your friends, and a plant that will deliver plenty of current and power continually at a low cost of construction and practically no operation costs.

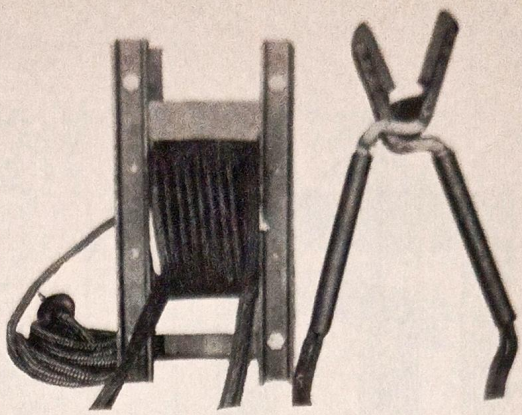
A simple but effective means of testing the efficiency of any wheel is to find the r.p.m. when running wild, or no load; then when under load, check the r.p.m. again. For full efficiency the r.p.m. under load should be one-half the no load speed. In other words the wheel in order to deliver full power must be turning with one-half the velocity of the water.

Also remember when checking the wheel, that the velocity must be taken out of the water if any power is to be transferred to the shaft. To test this, watch the wheel in operation. If the velocity is being used to its full advantage, the water upon hitting the buckets will fall as a dead weight directly downward. If instead it splashes back or forward from the buckets, possible power is being left in the water. This can usually be eliminated by adjusting the bucket arrangement or the line of fall.

CHAPTER VIII

Miscellaneous

¶ 1—A SOLDERING TRANSFORMER



Front View

THE core for the winding is made from a piece of soft pine 6" long, 2 1/8" high by 2 1/8" wide. See Fig. 1. Round off the edges slightly on the four long sides of the core. On the widest side of the core start one inch from the top and draw a diagonal line to within one inch of the bottom. Saw the core in two parts along this line. Sandpaper both sides of the cuts thoroughly and apply paraffin to the surface of both pieces. The diagonal cut and the paraffin will make it easy to remove the core from the winding. Chuck the core in a lathe or some other holder that will be satisfactory for turning, when placing the winding on the core. If there is difficulty in holding the two-piece block in the chuck, use wood screws to hold the block together until the winding has been finished. On the core wind three layers of .015 armature paper finishing the turns on the top of the core so that the end of paper will be in the direction of winding. This will assist in holding it on the core as the wire will tend to pull it tighter as the wire is wound on. The paper should be temporarily held on the core by a few turns of cotton tape until the winding is started.

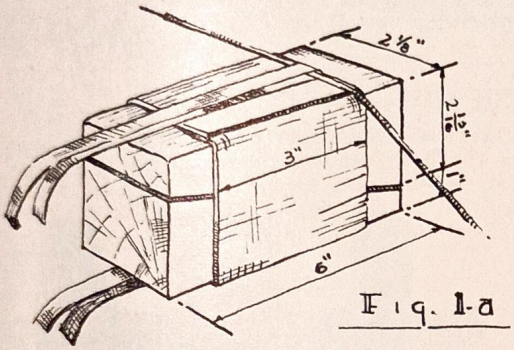


Fig. 1-a

STARTING THE WINDING

Notice in Fig. 1-a how a piece of cotton tape is laid under and around the first turn of the coil. Cut a strip of tape about 12" long and lay it on top of the core so that the middle of the tape will be under the first turn of wire. Make a half of turn and repeat this procedure on the bottom of the core. Putting the tape under the first turn on the bottom the same as on the top. Starting the turn about 1/16 of an inch from the end of the armature paper. As the first turn is completed pull the tape over so that the second turn of the coil will lay on both pieces of the tape. The part of the tape that is wrapped around the first layer will hold the turns from slipping off the form as the other turns are placed on it. This is repeated on the bottom the same as on the top. On the third turn move both ends of the tape back so that the wire will lay on the paper. Every third turn weave the tape under and over the turns as the winding progresses, until about an inch of wire is laying on the form. Then take a rubber band and place it over the tape to hold it in place while finishing the winding.

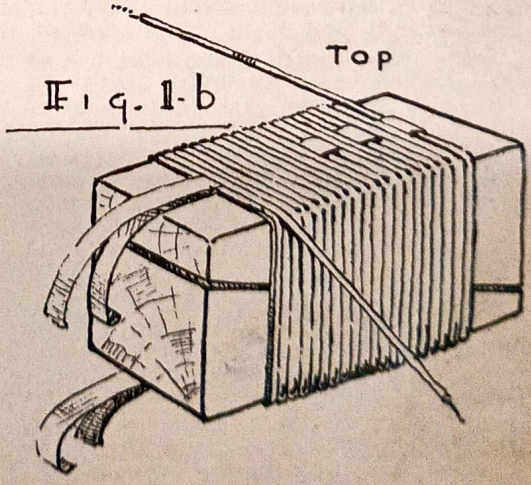


Fig. 1-b

When the first layer is wound, cross the wire over either on top or the bottom of the form. See Fig. 1-b. As this cross over is made slip a piece of .015 paper under the beginning of the turn. This paper should be cut 3″ wide and long enough to wrap once around the form with a slight lap. When the second layer is started remove the rubber band and place the tape over the first turn in the same manner as the first layer was wound. Weaving the tape over and under for the first six turns on the top and bottom of the coil.

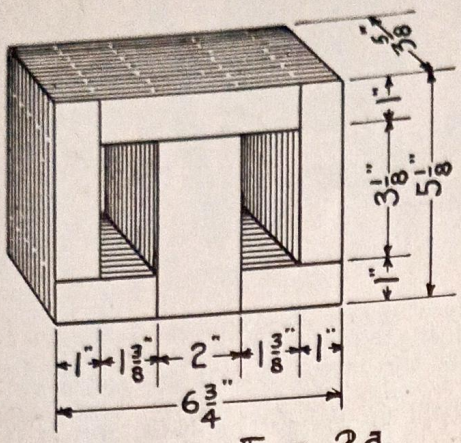


Fig. 2a

Follow the same methods throughout the winding of the primary until 250 turns of No. 14 S.C.E. have been wound on it. Be sure that only one thickness of paper is used between layers as all of the space is needed. After the primary has been wound put on a few turns of cotton tape to hold the winding intact until it is removed from the core.

Remove the core from the coil by tapping the small part of one end. Then tape the coil and solder the desired length of two conductor cord, necessary to connect it to an outlet.

CUTTING AND STACKING THE LAMINATIONS

The laminations should be cut and stacked according to the dimensions given in Fig. 2-a. The stack of the laminaitons could be started on the edge of a bench, building them all up into an E shape, so that the windings will slip on to the middle leg.

After the stack has been made, pull the entire stack over to the edge of the bench and clamp it with two clamps made from 1″x8″ angle iron or any other available material. See Fig. 2-b. Place the entire stack on a flat metal surface and tap the laminations so that they will all line up properly.

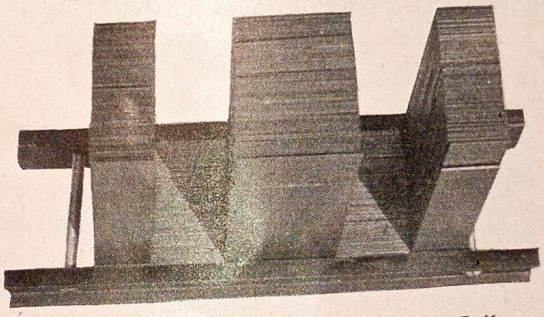


FIG. 2-B. E Shape Stock Ready for Coil

Place the primary coil on the middle leg and wrap around it ten turns of two number six lead wires. These wires are in parallel to give the capacity of a number 3 wire. While the lead wire makes the job much easier, they could be supplemented with solid or any other combination of wires that would give the carrying capacity and fit in the window of the transformer.

After the secondary has been put on the transformer, fill inside with the pieces to close the gaps at the ends of of the E and put another set of clamps on this side. Tap the entire assembly so that the pieces will butt together properly and make as perfect a joint as possible. While fiber placed between the clamps and the laminations will add to the appearance and eliminate some of the hum, it is not essential. See Fig. 3.

The specifications were written for stove pipe iron so that everyone could obtain it in their own locality. But if silicon is available, use one third less iron and reduce the turns in both windings one-third. For twenty-five cycle current keep the turns the same, but increase the iron one-third; unless silicon iron is used, in that case make the stack the same size as the stove pipe iron.

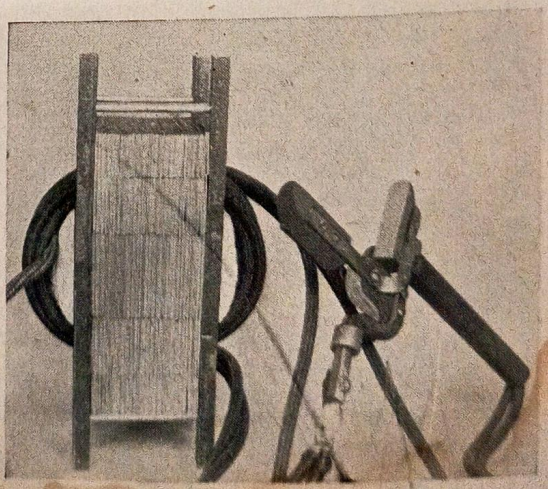


FIG. 3. Finished Job with Soldering Pliers

For 230 volts double the turns in the primary winding only and use one-half the size of wire.

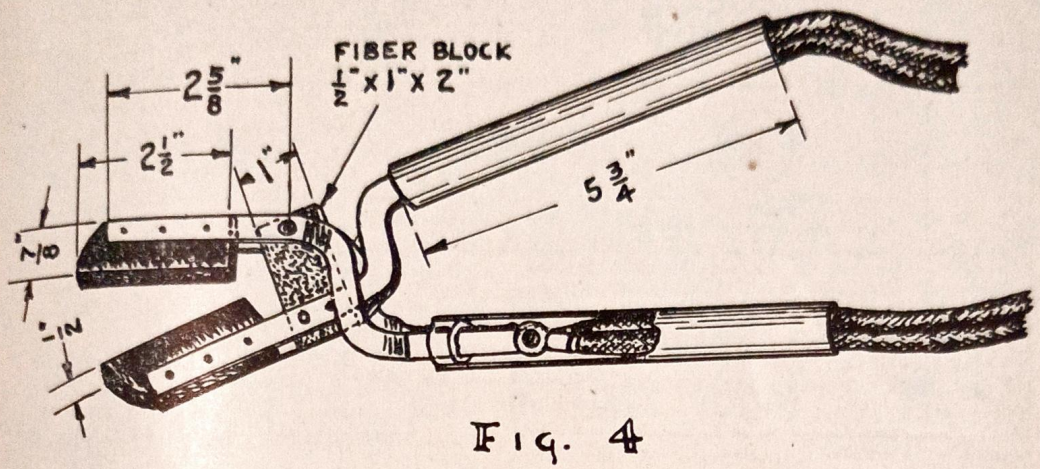


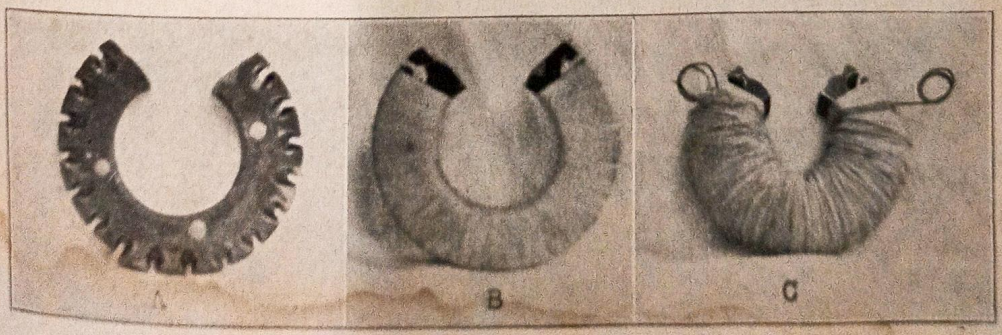
FIG. 4.

FIG. 4. Picture of Soldering Pliers Construction and Dimensions. The Frame Work Consists of Copper Strips ⅜" Wide by ⅛" Thick to Which Are Mounted the Carbon Blocks for Gripping the Work. The Insulating Handles Are Fiber Tubing ⅜" Inner Dia., 1/16" Wall.

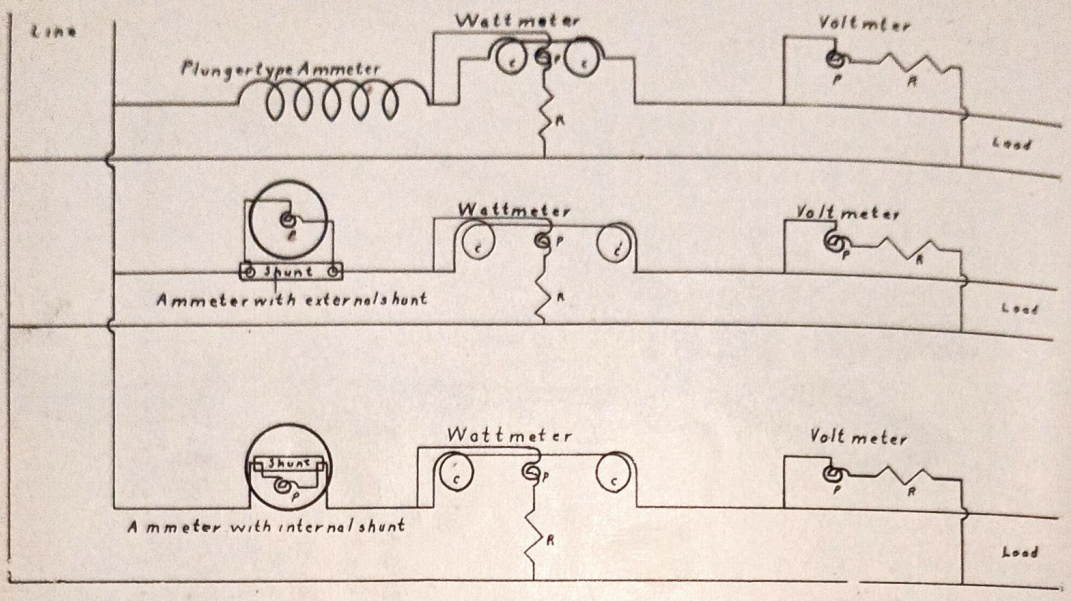
¶ II.—A GROWLER FROM A POWER HOUSE FORD ARMATURE

After stripping the armature place it in a vise and with a hack saw cut three teeth out of the laminations, sawing through the laminations below the rings that hold them together. Then take a wire and tie the laminations together at the points that have just been sawed. With a chisel shear the studs off that hold the laminations to the armature and peen the studs to the laminations. Insulate the laminations by winding two layers of cotton or friction tape over them. Then wind 1½ pounds of No. 17 S.C.E. wire on the laminations, leaving about ¾ of an inch space at each end. All the turns are wound in the same direction. Connect a No. 16 two conductor lamp cord to the start and finish of the winding and secure the lamp cord to the growler so no strain will be put on the winding.

The plate shows the progressive steps of the winding.



CONNECTIONS FOR METERS



¶ III—MAGNETIZER FOR MAGNETO MAGNETS

Follow the same specifications as given for the reactor used in conjunction with the Dodge generator for welding, but wind each of the coils with five pounds of No. 12. Leave a gap of about one inch at one end between the two poles. Use a 6 volt storage battery to supply the current. Place the magnet to be charged across the two polls and turn the current on. Then with a hammer tap the sides of the magnet lightly while it is being magnetized.

¶ IV—GASES FROM WATER

An Experiment in Electro-Chemistry

Water can be easily separated into the two gases, oxygen and hydrogen, by the action of an electric current. There are two other methods, in one of which the water must be first converted into steam, and the third by use of chemicals. Either the steam or chemical method can be relied upon to decompose the water, but the electrical method is now extensively used in the industries where pure hydrogen is required. Pure hydrogen, for example, must be employed in converting cotton seed oil into solid fats suitable for food.

When water is the conductor between two terminals, with five or more volts between them, oxygen is liberated at one pole and hydrogen at the other. For every cubic foot of oxygen liberated there will be two cubic feet of hydrogen. If one pound of water is gasified, there will be 14.2 ounces of oxygen and 1.8 ounces of hydrogen, because water is 88.81 per cent oxygen and 11.19 hydrogen. One cubic foot of oxygen weighs almost 1.42 ounces, which means that one pound of water produces ten cubic feet of oxygen. One cubic foot of hydrogen weighs nearly .09 ounces. This 1.8 ounces of hydrogen would have a volume of 20 cubic feet. When the gases are separately collected, the total volume is 30 cubic feet of hydrogen and oxygen. If combined, the result is an explosive mixture.

if separately collected, the 20 cubic feet (1.8 oz. of hydrogen) when burned will raise the temperature of 6.376 pounds of water 1 degree F. The amount of heat and the high temperature obtained by burning the hydrogen has prompted many people to assume that hydrogen obtained by the electrical method could be profitably used for power purposes. Unfortunately for the assumption that heat energy obtained from the hydrogen is less than the electrical energy required to produce the gases. Much higher efficiency is obtained when the electrical energy is used directly as in an electrical furnace.

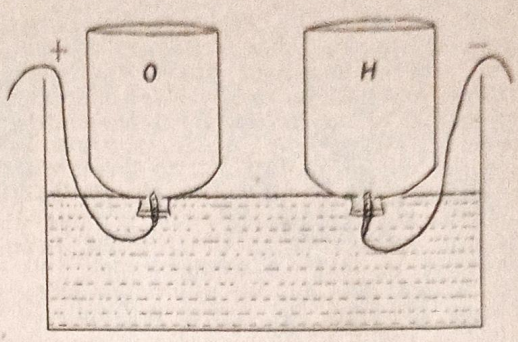


Fig. 1 showing general set up of experiment. The leads may be tipped with ribbon wire to give more surface, although this is not necessary. In commercial electrolysis a non-corrosive tip is used, such as platinum. By adding a few drops of sulphuric acid the water in the tank will be made a much better conductor. It is well to keep in mind when making this experiment that free hydrogen is highly combustible. No doubt you have read about its properties in the newspaper stories of the recent Hindenburg disaster.

In the early history of the electrical industry water ammeters, as they were called, were extensively used to measure electrical current. They were just as reliable and easier to use than the silver and copper plating devices. If for no other reason, the energy lost in the devices stopped their commercial use.

¶ V—BUILD YOUR OWN GENERATOR TEST BOARD

A valuable improvement can be made in the work bench through the use of a generator test board built into a compact unit. This home-made board, while not having the efficiency and refinement, will prove as useful as one of expensive make and manufacture. The motor for driving the generator to be tested is the most important piece of equipment. In order to be adaptable to all types of generators it should be reversible, variable speed design.

FIGURING THE NEW WINDING

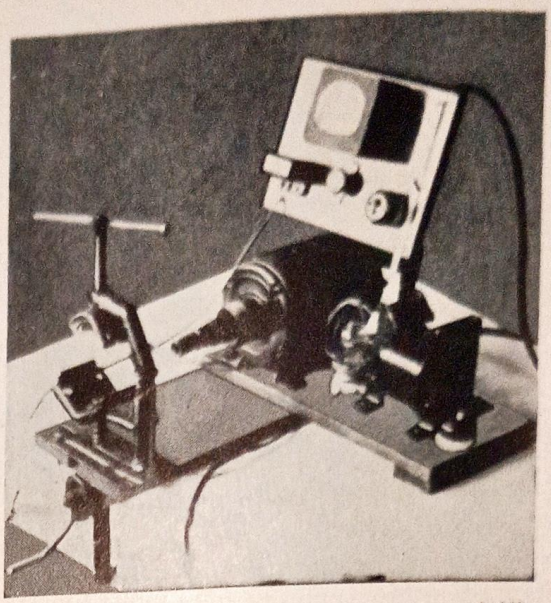
In building this particular board, as shown in the illustration, it was decided to convert an old Dodge generator into the motor. After taking down the generator, the design for the new winding was estimated through a compromise made between "rule of thumb" data and the material at hand. The number of turns per coil in the armature was figured as follows: In stripping the armature it was found that the original winding had four turns per coil and had delivered approximately 14 volts as a generator. This was equivalent to three and one-half volts per turn. Using this as a basis for 110 volts as a motor, the number of turns required per coil should be 31. A trial was made using No. 20 S.C.E. and it was found that 30 turns could be used quite nicely. The coils can either be wound in the armature one at a time or made up individually for form winding the armature. The original coil span and commutator connections would be used. That is, the coils would lie in slots one and seven, and the coil leads would be connected to the commutator bars one and thirteen.

LAYING IN THE COILS

After the first coil is laid in the slot and the proper commutator connections made, the others will follow in sequence. Each slot is insulated with a double thick-

ness of .007 paper, cut wide enough so that the paper extends slightly beyond the laminations and above the slots about one-half an inch. When the bottom half of the coil is laid in the slot, a single thickness of armature paper is placed on top of this coil to insulate it from the coil to be laid in the top half of the slot. This separator is tamped down thoroughly as the winding progresses to make a compact and well-insulated job, and to allow the maximum space for the coil in the top half of the slot.

As the coils are finished, the paper is trimmed at the slot, allowing for enough to be bent over, and held in place by the usual wedge. The coil span and commutator connections are the same as shown in the 25-bar D.C. layout in the changes for Dodge generators.



Completed Test Board Showing Mounting of All Equipment

It will save time and effort if each coil is checked for grounds as the winding proceeds; and as the coils prove to be free from grounds, they can be connected to the correct commutator bars ready for soldering.

When the armature is wound and soldered, test it again for short circuits and grounds. If it tests free from shorts and grounds, turn the commutator in a lathe and test it again for short circuits. Then undercut the mica between the bars. When finished, dip in varnish and leave to dry or bake, depending on the type of varnish being used.

FIELD COIL CONNECTIONS

The original field coils are used in this machine. By several tests it was found that the best results were achieved by connecting the shunt and series coils in parallel, and by reversing the ends of the fields one with the other it was easily determined which was the proper connection, as one connection would have a much higher torque than the other. This connection is shown in Figure 2; to make the test try reversing leads A and B.

While running the test, considerable sparking was noticed. This is something that it is impossible to eliminate in A. C. motors of this type as it can be accomplished only by an increase in the number of bars in the commutator. This job for the best results would require at least a 99 bar commutator. However, you will see that this difficulty has been overcome to some extent by the changes outlined. By removing the pole pieces and cutting about $\frac{3}{16}$" off of the long sides of them, it was found that the resulting narrower pole piece greatly reduced the sparking when running the motor on alternating current. Each pole piece should be cut the same; the edges filed to a smooth finish.

MOVABLE BRUSH MOUNTING

The brush holder was made movable so as to get rotation in either direction. The ring which originally held the third brush was rigged to hold both brushes. A lug was welded on the opposite side of the ring. This lug was similar to the original third brush lug. The exact position for drilling the bolt hole in this extra lug must be such that the two brushes (one reversed) will have a space of almost four clear bars between them when resting on the commutator. See Fig. 2. This correct spacing was found important.* in order to avoid excessive sparking. An extension was welded to one of the lugs to act as a lever, when moving the assembly. Complete reversal of the motor requires almost 180 degrees movement of this lever. To accomplish this it is necessary to cut away the two bridge pieces of the end plate.

*Note: 6¼ bars is the usual span, but to reduce sparking only part of the armature winding is being worked.

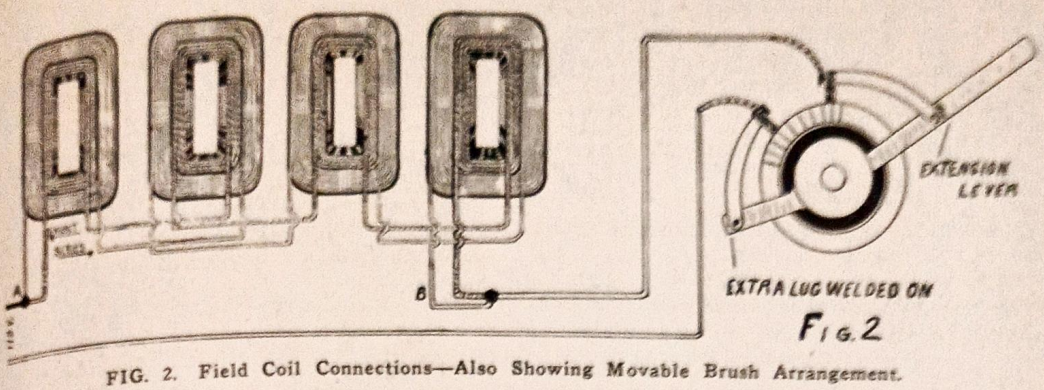


FIG. 2. Field Coil Connections—Also Showing Movable Brush Arrangement.

It is also necessary to cut away a little at each end of this enlarged opening so as to get sufficient movement of the lever.

This brush holder assembly is held in position with two ¼" bolts passing through the holes in the end plate where the original leads from the generator were taken out. These two bolts had lugs welded to one side of the heads, and then ground off so as to clear the brushes. A short spring was used under the nut of each bolt so as to hold the ring up snugly and yet allow for easy movement. To insulate each brush, the same bolts and fiber bushings were used as in the original set-up. (Make sure that these are all in good conditions.) It is only fair to say that a certain amount of cutting and trying was necessary to get this assembly working right.

New holes were needed in the bonnet holding the brushes. The proper place for drilling these holes is found by assembling the motor and clamping the bonnet in position without the use of the original screws or through bolts. The motor is started and the brush holder and bonnet are moved in both directions until a position is found for full torque in either direction by a 180 degree movement of the lever. When this location is found, mark and drill the holes to match the ones in the frame or bonnet on the other end. Flexible leads about five inches long are then connected to each brush.

Tests have shown that this motor will give satisfactory results for test bench work. It will drive any standard 6-volt car generator to deliver 15 amps.

ADDED DEVICES INCREASE USEFULNESS

The completed motor is mounted to the test board as shown in the illustration. A device is added for holding the generators in position while the test runs are being made. This is made from an old screw jack, rigged up for setting the height of the lower jaw. An old socket with the square opening pointing out is welded to the gear on the motor shaft. A short length of ½" square steel (as used with socket wrenches) is inserted in this socket to complete the coupling with the generator to be tested. This square steel piece fits into another socket fitted over the end nut on the generator. Thus, regardless of the type of generator being tested, by changing the size of the socket a handy connection can be made. Most socket sets have a short length of square steel (about two inches long, with balls set in each end) which is just right for this purpose.

A control panel is mounted above the motor as shown in the illustration. An ammeter calibrated so as to read 30-0-30, a home-made growler, test lamp and leads complete the unit.

¶ VI—NOISE FILTERS

A.C. GENERATOR NOISE FILTER

The inexpensive home-made solution for filtering the noise out of a 500-watt self-excited generator described here is equal in performance to a manufactured unit costing many times as much. The one thing important to remember in filtering is

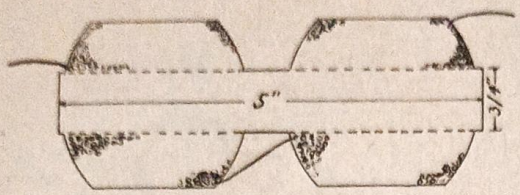


FIG. 1. Showing spacing of coils on tube

that chokes and condensers should always be placed as close to the machine as possible, so as to prevent radiation from the generator leads.

MAKING THE CHOKE COIL

After securing a fiber tube or wooden cylinder three-fourths inches in diameter and five inches long, on each end wind a coil consisting of 140 turns of 17 SCE wire, plain layer-wound. Each coil is spaced as shown in Fig. 1 in order to reduce self-capacity, which would act as a high-frequency by-pass and nullify the reactive effect of the choke.

CONNECTING FILTER

Connect the choke in series with the lead coming from the collector ring which is insulated from the frame. Shunt each side of the choke to the other generator lead with a 1 mfd. paper condenser, 200 volt rating. This filter is adequate to filter the noise out of the 110-volt a. c. line. Schematic diagram shown in Fig. 2.

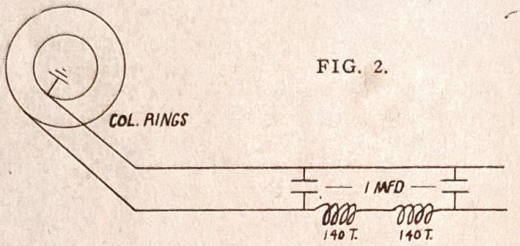
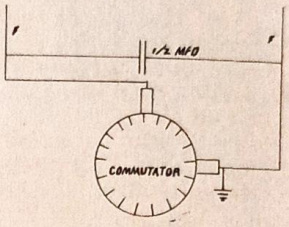


FIG. 2.



FILTERING SELF-EXCITED SECTION

In order to take out the commutator ripple which might be radiated by the exciter section of the generator, it is necessary to shunt the exciter brushes with a ½ mfd. condenser. For best results fasten the condenser direct to the brush terminals. See Fig. 3 for circuit diagram.

FILTERS FOR D.C. OPERATION

No diagrams have been shown for filter circuits for D. C. current, as this is primarily confined to one condition and that is the use of a condenser to bridge contacts for absorption of spark, and for such a condition the approximate recommendation can only be made, and that is approximately 1 mfd. per 300 watts load. The condenser required for such operation should be selected for D. C. working voltage in accordance with the circuit requirements.

In selection, condensers for bridging contacts to absorb spark on a resistance load, such as lamps or heaters of non-inductive type, operated from 110 volt circuit should use 220 D. C. working volt condensers, and when operated from 220 volt circuit it should be equipped with 400 D. C. working volt condensers.

If circuits are of the high inductive type the voltage peaks or surge often run many times the operating voltage, and this must be determined before installation of condensers, otherwise failure will result.

It has been found that by test in circuits of a high inductive type, operating on a 110 volt D. C., that it was necessary to use condensers of 600 D. C. working volts; and in some cases the peak voltage has been

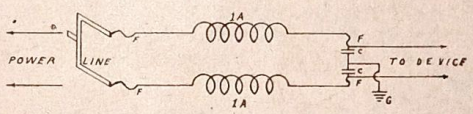


FIG. 1. FOR MISCELLANEOUS DEVICES

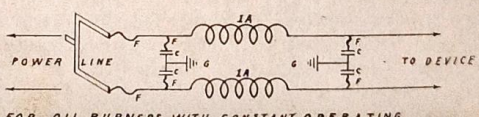


FIG. 2. FOR OIL BURNERS WITH CONSTANT OPERATING IGNITER PLUGS

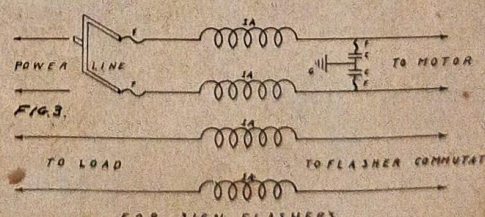


FIG. 3. FOR SIGN FLASHERS

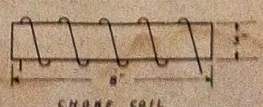


FIG. 4.

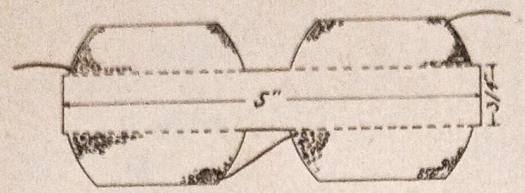


FIG. 1. Showing spacing of coils on tube

that chokes and condensers should always be placed as close to the machine as possible, so as to prevent radiation from the generator leads.

MAKING THE CHOKE COIL

After securing a fiber tube or wooden cylinder three-fourths inches in diameter and five inches long, on each end wind a coil consisting of 140 turns of 17 SCE wire, plain layer-wound. Each coil is spaced as shown in Fig. 1 in order to reduce self-capacity, which would act as a high-frequency by-pass and nullify the reactive effect of the choke.

CONNECTING FILTER

Connect the choke in series with the lead coming from the collector ring which is insulated from the frame. Shunt each side of the choke to the other generator lead with a 1 mfd. paper condenser, 200 volt rating. This filter is adequate to filter the noise out of the 110-volt a. c. line. Schematic diagram shown in Fig. 2.

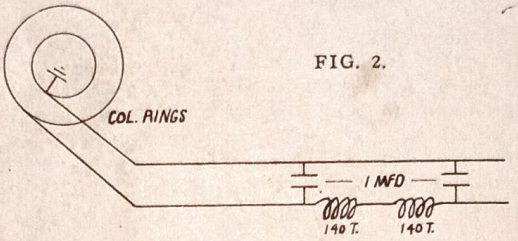
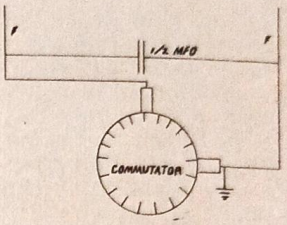


FIG. 2.



FILTERING SELF-EXCITED SECTION

In order to take out the commutator ripple which might be radiated by the exciter section of the generator, it is necessary to shunt the exciter brushes with a ½ mfd. condenser. For best results fasten the condenser direct to the brush terminals. See Fig. 3 for circuit diagram.

FILTERS FOR D.C. OPERATION

No diagrams have been shown for filter circuits for D. C. current, as this is primarily confined to one condition and that is the use of a condenser to bridge contacts for absorption of spark, and for such a condition the approximate recommendation can only be made, and that is approximately 1 mfd. per 300 watts load. The condenser required for such operation should be selected for D. C. working voltage in accordance with the circuit requirements.

In selection, condensers for bridging contacts to absorb spark on a resistance load, such as lamps or heaters of non-inductive type, operated from 110 volt circuit should use 220 D. C. working volt condensers, and when operated from 220 volt circuit it should be equipped with 400 D. C. working volt condensers.

If circuits are of the high inductive type the voltage peaks or surge often run many times the operating voltage, and this must be determined before installation of condensers, otherwise failure will result.

It has been found that by test in circuits of a high inductive type, operating on a 110 volt D. C., that it was necessary to use condensers of 600 D. C. working volts; and in some cases the peak voltage has been

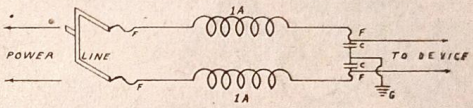


FIG1. FOR MISCELLANEOUS DEVICES

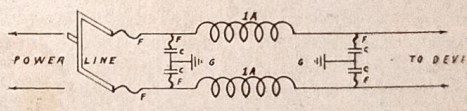


FIG.2. FOR OIL BURNERS WITH CONSTANT OPERATING IGNITER PLUGS

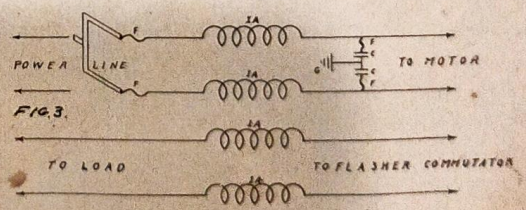


FIG.3. FOR SIGN FLASHERS

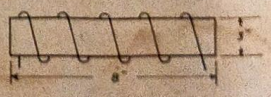


FIG.4.

COPPER WIRE TABLES

Giving Measurements at 68° F. (20° C.) with Specific Gravity of 8.89 (Brown & Sharpe)

A. W. G. B. & S. Gauge	Diameter Inches	Area Circular Mils	Weight Pounds per 1000 Feet	Length Feet per Pound	RESISTANCE Ohms per 1000 Feet	RESISTANCE Ohms per Pound
0000	0.4600	211,600.	640.5	1.561	0.04901	.00007652
000	0.4096	167,800.	507.9	1.969	.06180	.0001217
00	0.3648	133,100.	402.8	2.483	.07793	.0001935
0	0.3249	105,500.	319.5	3.130	.09827	.0003076
1	0.2893	83,690.	253.3	3.948	.1239	.0004891
2	0.2576	66,370.	200.9	4.978	.1563	.0007778
3	0.2294	52,630.	159.3	6.276	.1970	.001237
4	0.2043	41,740.	126.4	7.911	.2485	.001966
5	0.1819	33,100.	100.2	9.980	.3133	.003127
6	0.1620	26,250.	79.46	12.58	.3951	.004972
7	0.1443	20,820.	63.02	15.87	.4982	.007905
8	0.1285	16,510.	49.98	20.01	.6282	.01257
9	0.1144	13,090.	39.63	25.23	.7921	.01999
10	0.1019	10,380.	31.43	31.82	.9989	.03178
11	0.09074	8,234.	24.92	40.13	1.260	.05053
12	0.08081	6,536.	19.77	50.58	1.588	.08035
13	0.07196	5,178.	15.68	63.77	2.003	.1278
14	0.06408	4,107.	12.43	80.45	2.525	.2032
15	0.05707	3,257.	9.858	101.4	3.184	.3230
16	0.05082	2,583.	7.818	127.9	4.016	.5136
17	0.04526	2,048.	6.200	161.3	5.064	.8167
18	0.04030	1,624.	4.917	203.4	6.385	1.299
19	0.03589	1,288.	3.899	256.5	8.051	2.065
20	0.03196	1,022.	3.092	323.4	10.15	3.283
21	0.02846	810.1	2.452	407.8	12.80	5.221
22	0.02535	642.4	1.945	514.1	16.14	8.301
23	0.02257	509.5	1.542	648.5	20.36	13.20
24	0.02010	404.0	1.223	817.7	25.67	20.99
25	0.01790	320.4	0.9699	1031.	32.37	33.37
26	0.01594	254.1	0.7692	1300.	40.81	53.06
27	0.01420	201.5	0.6100	1639.	51.47	84.37
28	0.01264	159.8	0.4837	2067.	64.90	134.2
29	0.01126	126.7	0.3836	2606.	81.83	213.3
30	0.01003	100.5	0.3042	3287.	103.2	329.2
31	0.008928	79.70	0.2413	4144.	130.1	539.3
32	0.007950	63.21	0.1913	5227.	164.1	857.6
33	0.007080	50.13	0.1517	6591.	206.9	1364.
34	0.006305	39.75	0.1203	8312.	260.9	2168.
35	0.005615	31.52	0.09542	10480.	329.0	3448.
36	0.005000	25.00	0.07568	13213.	414.8	5482.
37	0.004452	19.83	0.0601	16664.	523.1	8717.
38	0.003965	15.72	0.04759	21012.	659.6	13860.
39	0.003531	12.47	0.03774	26497.	831.8	22040.
40	0.003145	9.888	0.02990	33411.	1049.	35040.

TURNS PER SQUARE INCH

B. & S.	Plain-enamel P. E.	Heavy Formvar H. F.	Single Silk-enamel S. S. E.	Single Cotton enamel S. C. E.	Double Cotton Covered D. C. C.
8	57	53	----------	52	48
9	72	67	----------	64	59
10	90	84	----------	80	76
11	113	105	----------	100	93
12	141	132	----------	124	114
13	177	165	----------	151	140
14	221	207	----------	187	171
15	277	259	----------	230	208
16	348	326	326	289	260
17	437	409	408	358	316
18	548	513	505	438	378
19	681	638	622	532	455
20	852	798	769	644	545
21	1065	997	946	780	650
22	1340	1255	1175	1008	865
23	1665	1560	1440	1220	1030
24	2100	1967	1775	1475	1215
25	2630	2464	2180	1790	1420
26	3320	3110	2680	2155	1690
27	4145	3883	3275	2590	1945
28	5250	4920	4030	3100	2250
29	6510		4865	3660	2560
30	8175		5890	4320	2930
31	10200		7170	5120	3330
32	12650		8560	5960	3720

as high as 1000 volts. This matter should be given due consideration before installation of condenser is made so that satisfaction can be had after installation.

On some sign flashers operating on A. C. it also is necessary to use condensers across the contacts to absorb the spark, but in most cases these need only be small capacities, from 1/10th to 1 microfarad, and selection must also be made in accordance with the type of circuit required. The arc at the contact of the A.C. type circuit is less severe than on D. C. current. In most cases the regular filter used for the correction of the other disturbances, proves most satisfactory and does not require the use of condensers at contacts.

DIAGRAMS OF FILTERING SYSTEMS

Figure 1 is for miscellaneous devices. The Fs in all the drawings are fuses. The Cs are condensers. 1A are choke coils. G is the connection to ground. The condensers are from 1/10th to 5 Mfd., depending upon the load that is drawn from the line. Normal requirements are 1 Mfd. for each 300 watts of load. The choke coils are 150 turns wound on a bakelite fibre or porcelain tube, 3″ in diameter. The size of wire wound on the tube will depend upon the load or current drawn through the line, and if the 8″ is not long enough where larger size wires are used, the tube may be made larger in length or shorter for the smaller sizes.

In Figure 3 of the circuit marked to motor is a motor that would operate the commutator flasher, and the bottom circuit is the circuit from the flasher commutator to the sign load.

¶ VIII—QUESTIONS AND ANSWERS

I have difficulty in soldering commutators. My iron seems to be hot enough, but the solder does not flow in the slots like it should. What would you suggest as a remedy?

Soldering a commutator is as easy as any other soldering job. However, the same principles must be carried out in all soldering. First, the riser, the slot, and the wires in the slots must be perfectly clean. Use only the very best grade of soldering paste and solder. The iron chosen to do the job should be in comparison to the size of one of the commutator bars, as copper is a very good conductor of heat, the heat from the soldering iron is dissipated very rapidly by the surface of the commutator bar, necessitating a soldering tip or iron four or five times as large as the commutator segment. Keep the soldering tip clean and hot enough to melt the solder when it contacts the iron, and you will always have a good soldering job.

After rewinding a split phase motor and being very careful that the winding was correct, it ran in the wrong direction. How can I change the direction without rewinding the motor?

This can be easily accomplished by reversing the starting winding from one side of the line to the other.

What makes a D.C. welding generator reverse its polarity while it is in operation?

This is a very difficult problem to prove, and the only way that the polarity could be reversed would be due to an instantaneous open in the shunt field winding that would be overcome by the opposite polarity of the series winding long enough to reverse the polarity of the machine. This open may have been due to a loose connection or a high resistance connection in the shunt fields of the welder generator, or in the exciter circuit.

What would be the advantage of an A.C. generator over a transformer for welding?

The A.C. generator output volts and amperes can be controlled by the field excitation, whereas the transformer is on the public power line and is subject to the loads that may be thrown on the power transformer by many other consumers. This is the reason that at times the welding transformer and apparatus do not work as satisfactorily as at other times, due to the variation of load on the power transformer.

Does it make any difference in putting the wire in an armature whether the wire is wound to the right or to the left?

It does not. The direction of rotation of the armature would not be affected whether the coils were wound in left handed or right handed, as the circuits would be the same.

What keeps the primary winding of a transformer from burning out when connected to the line?

The iron core in the transformer absorbs the flux created by the winding.

A radio transformer secondary is rated at 180 V. Why will it not light a lamp?

The current capacity of the transformer is too low to give enough current to light the lamp.

What is high tension electricity?

Any voltage over 550 V. is considered high tension. But high tension is generally considered to mean the primary wires of a power circuit, which are generally not lower than 2300 V. The amperage is low in comparison with the voltage.

In an electric heating unit, why is it that the unit gets hot and wire that is feeding it does not?

The heating unit is not a short circuit. It is a load, as the resistance in the circuit is a heater unit, and the current is dissipated in heat.

What size wire should be used in the wiring of a house for 6 or 12 V.?

Where the entire run or circuit (that is the distance from the entrance switch to the light, back to the switch again) does not exceed 100 ft. No. 10 wire will be satisfactory.

What must be done when changing the direction of rotation on a D.C. generator?

The field connections at the brushes must be changed one with the other.

When a D.C. generator operates at variable speed, is it necessary to have a battery connected to it?

Yes, as the battery will keep the voltage constant.

¶ VIII—QUESTIONS AND ANSWERS

I have difficulty in soldering commutators. My iron seems to be hot enough, but the solder does not flow in the slots like it should. What would you suggest as a remedy?

Soldering a commutator is as easy as any other soldering job. However, the same principles must be carried out in all soldering. First, the riser, the slot, and the wires in the slots must be perfectly clean. Use only the very best grade of soldering paste and solder. The iron chosen to do the job should be in comparison to the size of one of the commutator bars, as copper is a very good conductor of heat, the heat from the soldering iron is dissipated very rapidly by the surface of the commutator bar, necessitating a soldering tip or iron four or five times as large as the commutator segment. Keep the soldering tip clean and hot enough to melt the solder when it contacts the iron, and you will always have a good soldering job.

After rewinding a split phase motor and being very careful that the winding was correct, it ran in the wrong direction. How can I change the direction without rewinding the motor?

This can be easily accomplished by reversing the starting winding from one side of the line to the other.

What makes a D.C. welding generator reverse its polarity while it is in operation?

This is a very difficult problem to prove, and the only way that the polarity could be reversed would be due to an instantaneous open in the shunt field winding that would be overcome by the opposite polarity of the series winding long enough to reverse the polarity of the machine. This open may have been due to a loose connection or a high resistance connection in the shunt fields of the welder generator, or in the exciter circuit.

What would be the advantage of an A.C. generator over a transformer for welding?

The A.C. generator output volts and amperes can be controlled by the field excitation, whereas the transformer is on the public power line and is subject to the loads that may be thrown on the power transformer by many other consumers. This is the reason that at times the welding transformer and apparatus do not work as satisfactorily as at other times, due to the variation of load on the power transformer.

Does it make any difference in putting the wire in an armature whether the wire is wound to the right or to the left?

It does not. The direction of rotation of the armature would not be affected whether the coils were wound in left handed or right handed, as the circuits would be the same.

What keeps the primary winding of a transformer from burning out when connected to the line?

The iron core in the transformer absorbs the flux created by the winding.

A radio transformer secondary is rated at 180 V. Why will it not light a lamp?

The current capacity of the transformer is too low to give enough current to light the lamp.

What is high tension electricity?

Any voltage over 550 V. is considered high tension. But high tension is generally considered to mean the primary wires of a power circuit, which are generally not lower than 2300 V. The amperage is low in comparison with the voltage.

In an electric heating unit, why is it that the unit gets hot and wire that is feeding it does not?

The heating unit is not a short circuit. It is a load, as the resistance in the circuit is a heater unit, and the current is dissipated in heat.

What size wire should be used in the wiring of a house for 6 or 12 V.?

Where the entire run or circuit (that is the distance from the entrance switch to the light, back to the switch again) does not exceed 100 ft. No. 10 wire will be satisfactory.

What must be done when changing the direction of rotation on a D.C. generator?

The field connections at the brushes must be changed one with the other.

When a D.C. generator operates at variable speed, is it necessary to have a battery connected to it?

Yes, as the battery will keep the voltage constant.

What controls the voltage and amperage output of an electric generator?

The voltage depends entirely upon the number of turns and the speed the armature is traveling and the intensity of the magnetic field. The amperage is controlled by the cross section area of the conductor in the armature.

How many amps will be required to cut about ½" thickness steam traction engine boilers? What type of carbons are used in cutting? Which is cheaper, oxygen-acetylene cutting or electric when the dynamo is operated by gas engine?

It would require 300 to 400 amps. A heavily coated ⅛" rod, similar to Autopower No. 66, is recommended as better than carbons. However, if the plates are to be used again, cutting them with oxygen-acetylene will permit doing so without shearing, because it leaves a much evener cut than the electric arc. While we have no definite figures on comparative costs, it is our opinion that there would be little difference.

I am using a converter connected to a 32 volt D.C. line that has an output of 110 volts A.C. I want to feed 110 volts A.C. and take off 32 volts D.C. When I try this the armature rocks back and forth and will not run, even if the speed is brought up to 3500. And when the 110 A.C. is connected to the converter, it will immediately begin to lose speed and finally stop.

There are several reasons why the machine does not work as an A. C. to D. C. converter. It would have to be brought up to a speed of at least 3600 before it was connected to the line, and it would be necessary to have the fields excited. And if a squirrel cage was not installed in the converter, the armature would hunt, be noisy and the efficiency of the machine would be very low.

I have rewound a generator and the armature and the field coils test satisfactory, but when I drive it the pull, or load, is so strong that it tries to stop the engine that is driving it. What could be wrong with this generator? I rewound one similar to it with good success.

Undoubtedly this is due to a short circuit either in the brush holders or the terminals—if the armature and field connections are correct.

How can a four pole 220-volt generator with a present rating of 1,100 r.p.m. be changed to deliver 32 volts at the slowest speed possible?

It is assumed that you anticipate using this generator for wind charging and for the lowest speed we would not recommend any change in the armature, but only to connect the shunt fields in parallel. If this does not give you the satisfactory results, remove one-third of the weight of the wire from the shunt coils.

If one cell of a six-volt battery is tapped, will it draw current from the other two?

As electricity travels the path of least resistance, there will be no load on the other two cells.

A welder made up of an electric vehicle motor is now driven with a Buick engine. It develops 250 amps, but the operator has to be very careful when striking an arc. While the engine can be choked very easily, the arc is not stable—too much fluttering. Would you advise a change in the field?

It is our opinion that your trouble is due to not using a reactor with the generator. Undoubtedly you would get much better results by separately exciting the machine.

Is it possible to change a 110-volt Universal motor for 32-volt service?

This could be done by rewinding both the armature and fields. To find the number of turns for the armature and field, count the number of turns in one armature and one field coil and divide this number by 110. This will signify the number of turns per volt. Example: Suppose the armature has 11 turns per coil. $11 \div 110 = .1$ turn per volt. Multiply the number of turns per volt by 32. $.1 \times 32 = 3.2$ turns per coil will be needed to change the armature for 32-volt service. The copper would have to be increased 3.2 times in circular mil area. This formula can be applied to the fields, too, and for changing 32-volt direct current motors and generators to 110-volt direct current. When the turns per coil are not a full number and the fraction is a half or over, make it a whole number. Example: 3.5 would become 4; 3.2 would become 3 turns per coil.

By rewinding the armature with one-fourth the number of turns and four times the size of wire, using the original commutator connections and coil span, and by winding a set of field coils with the same weight of wire four times the size, it would work satisfactorily on 32 volts. This would also apply to the changing of any 110 volt D.C. motor or generator to 32 volts, provided you do not wish to make any change in the speed.

I am experiencing trouble in getting the number of turns in the armature.

It is possible and a comparatively easy job to get the number of turns as specified in the slots. The only requirement is that the wires be laid straight in the slot and tamped down as the winding progresses. All of the specifications given in the book have been thoroughly tested and will give entire satisfaction when the directions are studied and followed.

If the fields of a power house generator are rewound with wire small enough so that the resistance of each field is equal to the resistance of the original six, then connect the new fields all in multiple, won't the increased field strength cut the charging rate?

There will be no increase for the new six in multiple will have the same resistance as the old six in series.

What size wire should I use for 12 volts current at a distance of 150 ft.?

The circuit would be 300 ft. long. Any size wire from number 6 or larger would be satisfactory for either 12 or 6 volts.

What can six volt starter motors be used for?

Due to the majority of them having sleeve bearings, very few things can be done with them, unless the armature shafts are machined to fit a generator frame with ball bearings.

By taking a model T starter armature and fitting it to a model T generator housing, and separately exciting the fields of the generator with 6 volts, it makes a good plating generator that will deliver over 100 amperes. If a number of turns of No. 8 lead wire are wrapped around the poles, each pole in opposite direction, and as many turns as possible, it will make a powerful 6 volt motor adaptable to toy cars, etc.

Is varnishing necessary?

Yes, to this extent—it makes the winding moisture and dust proof, and helps to protect them from centrifugal force by holding them in place.

¶ IX—DEFINITIONS

A—The symbol for area.
A. C.—Alternating Current.
Accelerate—To increase in speed.
Accessories—Parts that go to improve or complete a machine.
Accumulator—A condenser; term formerly applied to a storage battery.
Adaptor—A device used to supplement or change the construction of application.
A. I. E. E.: American Institute of Electrical Engineers.
Air Gap—The space between two elements, as in a motor. The space between the rotor and stator.
Alloy—A combination of metals.
Alternate—Changing in intensity or polarity.
Alternating Current Motors—Single phase, any motor that operates on current produced in one phase. Polyphase, any motor that operates by current produced by more than one phase, generally a two or three phase motor.
Alternator—An electric generator which produces alternating current.
Ammeter—Instrument used to show the current flow.
Ampere—Unit of current. The amount of electricity that flows at a pressure of one volt through a circuit of one ohm resistance.
Ampere Turn—Number of turns in a coil multiplied by the number of amperes flowing in the circuit.
Angle—See phase angle.
Anneal—To soften by heat treating.
Annunciator—A device, electrically operated, used to make an indication by sound, symbol, or both.
Apparent—Seemingly, as apparent wattage.
Appliance, Electrical—Any device that is adaptable for service on an electrical circuit.
A. R. A.: American Railway Association (formerly Railway Signal Association).
Arc—An electric current flowing through space from one point to another.
Area, Plane—Amount of space covered. The cross section of a wire expressed in circular mills.
Armature—That part of an electric machine that collects the current or causes a counter E. M. F. It may rotate or be stationery.
Arrestor Lightning—A protective device from lightning applied to electrical circuits.
Artificial Silk: A fibre of silky appearance produced from specially prepared cellulose.
A. S. T. M.: American Society for Testing Materials.

Auto Phase Changer—A transformer used on a polyphase power supply to operate motors designed for a different phase.
Auto Transformer—A transformer used for some special voltage change.
Bake Oven—Oven used for baking electrical windings before and after being treated with varnish. Average temperature 212 degrees Fahrenheit.
Balance Coil—Auto transformer used for obtaining a number of low voltage circuits from an alternating current distribution system.
Balance Transformer—A transformer with both primary and secondary windings alike, but the secondary tapped for one or more low voltages.
Band—A number of turns of twine or wire placed around an armature or rotor to hold the winding in place.
Bar Segments—The current carrying part of a commutator.
B and S—Brown and Sharp wire gauge same as American Standard.
Base—That part of a machine that supports the whole part.
Battery—A number of electric cells connected together.
Battery Charger—A device for charging storage batteries.
Bearing—The part of the end house the shaft rests directly on.
Binding Post—Part of an electric machine or instrument to attach wires to.
Booster Transformer—One used to boost the secondary voltage of a low voltage line.
Generator—Used in conjunction with another generator to maintain a steady current.
Braid: A plaited covering.
Braided Cable: A cable in which the wires are interlaced or plaited instead of twisted.
Brake Pony—Brake used to estimate torque of an electric machine at its shaft.
Breaker Circuit—A protective device used where fuses would be impracticable. Usually automatic and can be adjusted to desired amperage.
Bridge, Wheatstone—Instrument used to measure resistance.
Brush—The part of an electric machine that contacts the commutator or ring to carry current to or from the rotating element, generally made from carbon.
Bulb—A glass-enclosed filament.
Bus Bar—Large rectangular copper bars used in switchboard work.
Buzzer—A vibrating signal device.
BX—Armored flexible conduit.
C—Symbol for capacity.
Cable—A number of small wires joined together for strength and flexibility.
Cailbrate—To adjust to some standard.
Calorie—Unit of heat.
Capacity—The rating of electrical apparatus. The farad is the unit of condenser capacity.
Carbon Pile—A number of thin pieces of carbon arranged so pressure can be applied to them. Used for resistance.
Carrying Capacity: The maximum current strength that a conductor can safely transmit.
Cartridge Fuse—A fuse made in cylindrical form with metal contacts on each end.
Catenary—Over-head construction of an electric railway.
Cell—One unit of a battery.
C. G. S.—Centimeter gram second.
Centimeter—1/100 of a meter.
Choke Coil—Generally a coil with an iron core used to retard the current flow in a circuit.
Circuit—A metallic path for distributing electricity.
Circular Mil: A circle having a diameter of one one-thousandth of an inch.
Circular Mil Foot: A one-foot length of a cylinder having a diameter of one mil.
Clips—Clamp contacts that hold by virtue of their spring qualities or by springs made to work them.
Clockwise—To the right.
Cords: Standard lengths of insulated conductor finished with tips or terminals or other devices to fit some special type of apparatus.
Cordage: Small conductors composed of a number of fine wires, or strands of tinsel and insulated (usually) by servings or braids of cotton or silk.
Core Wire: A soft iron wire having practically no residual magnetism.
Closed Circuit—A circuit complete from source to destination.
Coil—A number of turns of wire.
Coulomb—A quantity of electricity flowing at the rate of one ampere for one second.
Collector Ring—Ring used to convey current to or from the brush to winding on the rotating element.
Commutator—That part of an armature that carries the current to or from the winding to the brushes.

Compensator—A starter for polyphase motors.
Compound—In a D.C. generator or motor, when the field coils have two windings, the smallest being shunted across the line and armature and the large one in series with the line or load.
Compound over—When the voltage increases with the load.
Compound under—When the voltage drops with the load.
Compound differential—When the series winding is of opposite polarity to the shunt.
Compound Insulating—Liquid used to impregnate windings to protect them from moisture and vibration.
Conductance—The ability to transmit electric current.
Conductor—Any substance that will transmit or carry electricity.
Connector—A metallic substance designed for joining conductors together.
Consumed—Dissipated energy in a form not to be recovered.
Contact—To touch firmly enough to complete a circuit. The parts of an apparatus which touch each other to complete a circuit.
Controller drum—Controller with many contacts arranged like a drum operated by a lever to vary the resistance in a circuit.
Converter Rotary—See rotary converter.
Core—That part of any electrical apparatus that the winding is laid on.
Counter clockwise—Turning to the left.
Corrosion—Waste caused from chemical or atmospheric conditions.
Crossarm—The cross members on poles used to support the conductors.
Cross section—To cut away so as to expose some internal part or feature. When wire is cut straight across, its end is the cross sectional area.
Current—Amperage.
Current regulator—A transformer designed to supply the circuit its feeding. Current at a constant value.
Current relay—A short circuit and current protective device for transmission lines.
Current transformer—A small transformer absorbing a small portion of the current used to operate a watt meter for power loads.
Cutout auto—Device used to disconnect a generator from its load when the voltage is lower than desired. A fuse block.
Cutout thermal—A large refillable plug fuse which breaks its circuit by heat action on its element.
Cycle Counter—Frequency meter.
Cycle—One complete alternation, from zero maximum zero maximum zero.
Damp-Proof: Having an insulation saturated in some non-absorbent material such as asphalt compound.
D. C.—Direct Current.
Data—Information gathered from facts.
Delta—A three-phase connection where the current of each phase travels through only ⅓ of the winding.
Dielectric—Insulating value.
Differential—See compound.
Direct—Current of constant polarity.
Directional relay—A protectional device for generators and parallel transmission lines.
Disconnect—To separate.
Distribute—To carry from one point to another.
Distribution—The system of carrying electrical power.
Double throw switch—A switch having a common connection that can contact two other points separately.
Drift—A tool used to tamp wires down in core slots.
Drop—Loss in pressure due to resistance or load.
Drum armature—An armature whose windings are arranged so they form a drum.
Dutchman—A metal filler.
Dynamic—The effect of force to produce motion.
Dynamo—A machine that converts mechanical energy into electric energy; a D. C. generator.
Dyne—The smallest unit of force.
Eddy currents—Stray magnetic currents circulating in iron. Prominent in solid poles.
Efficiency—Amount of work accomplished compared with energy required to do the work.
E. M. F.—Electro motive force.
End housing—The part supporting the bearings on electrical machines.
Energy—The capacity for doing work.
Engine Driven—A machine whether directly connected or belt driven by an engine.
Entrance switch—The first switch feeders are connected to after they enter a building.

Equalizer—The switching arrangement for compound wound D.C. generators, or synchronous converters.
Exciter—Direct current generator or battery used to supply current for the fields of another generator.
F.—Symbol for force.
Fabric treated—Any fabric treated with varnish or other insulating compounds.
Faces pole—See pole faces.
Farad—The unit of capacity. It is equal to one billionth C.G.S. Unit.
Feeder—A large conductor.
Fibre—A hard paper base product produced by tremendous pressure.
Field—The area or space affected by lines of force. Its intensity depending upon the force establishing it.
Filter—Devices used to eliminate line or electrical machinery noises. Usually a combination of choke coils and condensers.
Fish paper—Thin fibre paper.
Fish tape—A flexible steel tape used to pull wires through conduit.
Flash-over—The arc caused from the breaking of a circuit.
Flexible coupling—A coupling connecting two axes together that continue to operate when they are not in perfect alignment.
Flood light—A powerful lamp used for outdoor lighting.
Floss Silk: A soft, smooth, loosely twisted filament silk.
Flux—Magnetic lines of force. A soldering compound.
Force—Any cause changing the motion of matter.
Frequency: Rapidity of changes in direction of an alternating current. Usually expressed in cycles per second or alterations per minute.
Frequency changer—A machine for changing the frequency of an electrical circuit.
Frequency convertor—A combination of machines that convert the power of an A.C. system from one frequency to another with or without effecting the phase.
Frequency meter—A meter to determine the frequency of an alternating current.
Friction—Energy dissipated by the rubbing effect of two masses of material.
Fuller board—A paper base board having some of the properties of fibre, but much softer.
Furnace (electric)—Any furnace deriving its heat from electric power usually by an arc.
Fuse—Protective device for electrical circuits.
Fuse Wire—A lead alloy wire.
G—Symbol of conductance.
Galvanometer—A sensitive apparatus for measuring current and voltage changes in an electrical circuit.
Gauge (wire)—American standard wire gauge. Used to measure diameter of wires.
Gauss—Unit of magnetic intensity.
General purpose motor—A poly phase motor designed for various applications.
Generator—A machine for converting mechanical energy into electrical energy.
Glazed Cotton: Cotton thread tightly twisted and given a hard glossy finish.
Gramme—Unit of Mass.
Grid—Cast iron resistance units.
Growler—A primary coil transformer used to test electrical windings, the winding being tested acts as a secondary winding.
Ground—Some part of a winding or circuit contacting the metal it is wound on or enclosed by. A circuit leading to earth.
H—Symbol of magnetic force.
Hard Drawn Wire: Wire as it comes from the drawing machines without annealing.
Hardened Wire: Wire which has been tempered after manufacture.
Heat—A form of energy produced by electrical, chemical, combustion or physical action.
Helix—Wound in spiral or as a coil spring.
Henry—A unit of inductance.
Holder—That which holds, supports, or retains in a way to prevent movement.
Horse power—Electrical energy expended at the rate of 746 watts per hour. Work accomplished at the rate of 33,000 foot pounds per minute.
Housing—That part of a machine that supports, protects, or both.
Hunt—An electrical machine is said to hunt when its rotor moves from one bearing to another to locate its magnetic center.
Hydro electric—Electric plant using water power as a prime mover.
Hysteresis—A dissipation of energy by heat. Generally caused by Eddy currents.
I—Symbol of current.
Impedance—The sum of ohms of resistance, capacity, and inductance.

Impress—To form or fix by pressure. Inductance of the voltage divided by the rate of change expressed in henrys.
Indicate—To show or point.
Induction—Transferring an electro motive force by magnetism.
Induction motor—A motor whose rotor is turned by a rotating magnetic field.
Industrial—Pertaining to or associated with industry.
Inert—Matter at rest. Motionless.
Insulate—To separate two electrical conductors by a non-conductor.
Insulator—Opposed to the flow of electrical current.
Internal—Pertaining to the inside.
K—Symbol for constant.
Kapp—The equivalent of 6,000 C.G.S. a unit of force for an area of one square inch.
Kilo—1,000 units.
Kilovolt—1,000 volts.
Klydonograph—A photographic line surge-recorder.
Knife switch—A switch having one or more narrow blades operating on the principle of a jack knife.
K. V. A.—One ampere at a pressure of 1,000 volts alternating current.
L—Symbol for self-inductance of an electric circuit, henrys.
Lag—When the amperage rise is behind the voltage rise in the cycle, of an alternating current, it is said to lag.
Lamination—Thin sheets of material generally used in building cores, pole pieces, and frames for electrical windings.
Lap winding—In a D.C. armature when the start and finish of a coil connects to adjacent bars, it is called lap wound.
Lateral—The distance a rotor of a motor or generator can travel between its bearings.
Lay: The length of one complete turn in multiple wires or cables. For example: 1" lay in twisted pair is one complete twist per inch.
Lead—When the amperage rise is ahead of the voltage rise in the cycle of alternating current, it is said to lead. Also feeders as a motor lead.
Lead batteries—A battery with lead plates.
Leakage—Loss of current from an undesirable cause.
Lenz's Law—The current in an armature is such as to oppose the motion producing it.
Lightning arrestor—A device to protect an electric line or circuit from lightning.
Line—Usual term for outdoor circuit.
Line of force—An electro magnetic wave.
Load—The amount of work a machine is producing.
Low voltage—Under normal or rated voltage.
Luminaire—Unit of light.
M—Symbol of mutual conductance, Henrys, of two electrical circuits magnetically connected.
Magnet—A mass of iron or steel that has properties to attract like material.
Magnetic—Having properties of a magnet.
Magnetic Circuit—A path traveled by lines of force as from one pole to another.
Magneto motive force—Forces produced from magnetism and motion.
Mass—Quantity of matter.
Manual paralliel—Paralleling by hand.
Maximum—Largest amount.
Mercury arc—An electric arc in mercury vapor.
Mica—A silicate made up of many thin transparent scales. Very high in insulating qualities.
Mico farad—One millionth of a farad.
Mil—A circle whose diameter is 1/1000 of an inch.
Minimum—Smallest amount.
Motor—A machine that converts electrical energy into mechanical energy.
Motor generator—A generator driven by an electric motor.
Multiple—More than one.
N—Symbol of turns in a coil or electrical circuit.
N. E. C. S.: National Electrical Code Standard (of the National Board of Fire Underwriters).
Negative—Having a negative polarity.
Neon—A basic gas.
Neutral—Neither.
Ohm—Unit of resistance.
Ohm's Law—To estimate the current divide the voltage by the resistance.
To estimate the voltage multiply the current by the resistance.
To estimate the resistance divide the voltage by the current.

Oil dash pot—A Plunger operating in a cylinder whose action is retarded by oil.
Oil switch—A switch with contacts operating in oil.
Oil transformer—Transformer using oil to carry the heat to the cooling flanges.
Open circuit—A circuit whose path is not complete.
Oscillate—To move backward and forward.
Output—Usually the product of voltage and amperage.
P—Symbol of average power, watts.
Panel board—A board of insulating material used for the mounting of instruments, switches, etc.
Paper (armature)—A paper of high insulating and mechanical quality.
Parallel—Where two or more paths for electric current are arranged so that current can flow through them without having to go through one to get to the other, it is said to be parallel.
Peak—Highest point.
Permeability—Ability to retain magnetism.
Phase—The power impulses generated by an alternating current generator.
Photo electric cell—A cell sensitive to light rays.
Pilot light—Indicating lamp usually working in conjunction with another circuit.
Pitch—The number of slots a coil spans. Also the number of commutator bars at the beginning and end of an armature coil span.
Plating—To plate with electric current.
Plug—That part of an apparatus that fits an orifice to complete a function with other parts of an electric circuit.
Polarity—Having a north or south pole attraction. Having some distinct quality.
Pole—One end of a magnet. The magnetism of one polarity created by one or more coils single or collectively.
Pole face—The area of a pole next to the rotating element in an electric machine.
Polyphase—More than one phase.
Porcelain—A clay product of high resistance quality.
Portable—Movable.
Positive—Of a positive polarity.
Potential—The amount of voltage.
Potentionmeter—A variable high resistance, low amperage rheostat.
Power—Intensity of force actually put forth. The rate at which work is done.
Power factor—The relation of the current to the voltage. The efficiency of an alternating current electro motive force.
Power relay—A load limiting device.
Power Transformer—A transformer of large capacity used in distributing power.
Precision—Exact, accurate.
Press Board—Same as Fuller board.
Prime mover—A basic or fundamental power as water, steam, wind, etc.
Primary—The first winding current flows through in an electric current apparatus. Elementary.
Progressive—Where an armature circuit advances one bar every time it goes around the armature, it is said to be progressive.
Pullout—To run below synchronous speed.
Push through winding—Windings made up of rectangular copper pushed into the slot from the side due to the small gap between the teeth.
Pyrometer—An electrically operated thermometer for reading high temperatures.
Q—Symbol for quantity of electricity.
Quantity—The strength of a current; the amount.
R—Symbol of resistance.
Radiation—To send out in waves, rays, or direct lines from a point or surface.
Ratio—The relation between two numbers or a magnitude of the same kind.
Reactance—The lag of current behind the voltage due to the iron core of a coil.
Reactive component compensator—A device used in conjunction with watt hour meters for obtaining the kilovolt ampere demand.
Reactor—Coil with iron core used to protect the supply source from surges of current caused by the load.
Recording instrument—An instrument that records by means of ink or some other suitable method for recording.
Rectify—Apparatus for changing alternating current to direct current.
Redisual—The permanent magnetism of a magnet or pole piece.
Relay—The electro mechanical device by means of which a current flows in one circuit makes or breaks a current in another, as an automobile generator cutout.
Reluctance—Permeance, ability to centralize self-contained lines of force.
Remote Control—Control from a distant point.

Repulsion—Induction—Motion produced by repulsion and induction.
Retrogressive—When the circuit of an armature after it has traveled around the armature drops back a bar, it is said to be retrogressive.
Reverse—To change in direction of motion or condition.
Rheostat—A variable resistance unit.
Riser—The part of a commutator bar that the armature winding is connected to.
Rotary converter—A direct current motor with its armature winding tapped and brought out to rings for delivering alternating current, or by having a separate winding on the same armature core for producing alternating current.
Rotor—That part of an electric machine that rotates.
Safety switch—A switch whose live elements cannot be touched when the switch is closed.
Segment—One bar of a commutator.
Series—Passing from one to another.
Shaft—The supporting element of a rotor.
Shift—To move in one direction or another.
Shunt—A conductor joined to two points in a circuit and arranged so that they divert part of the current.
Short circuit—A circuit closed by an unnatural condition before it reaches its intended destination.
Silicon steel—Sheet steel used in motor and transformer cores.
Sleeving—Insulating, tubing, generally cotton.
Slip ring—A ring mounted on a rotor shaft to convey current to or from the winding.
Slot—The space in the laminations of a rotor or stator for the winding to be placed in.
S. P.—Abbreviation for single pole.
Solder—To join together by a tin and lead combination with the application of heat.
Spacer—A filler or some material of insulating property to separate conductors.
Spaghetti—Varnished linen or cotton tubing, having a high glossy finish.
Span—The number of teeth a coil in any winding extends over, also see pitch.
S. P. D. T.—Abbreviation for single pole double throw.
Specific gravity—The exact weight relation of a solid or liquid to pure water.
Speed indicator—Device used to calculate the speed of a shaft.
Speed reducer—Gearing attached to a motor shaft to reduce the speed.
Split phase—Two separate paths for the same current as in a split phase motor.
Squirrel cage—The bars and rings of a polyphase motor arranged like a revolving squirrel cage.
Standard—A guage for accuracy or quality.
Star—A three phase winding in which current must flow through two legs of the winding to complete its path.
Starter—A compensator or controller used to start motors.
Starting winding—The winding used in a split phase motor to give torque to the rotor, but is not used after speed is attained.
Storage battery—A number of electric cells connected together that are able to produce or absorb electric energy by chemical action.
Strain insulator—An insulator designed to relieve strain or stress.
Sub station—A remote subsidiary of a power plant used to boost, lower or change the frequency or character of current.
Suppress—To retard, hold back.
Surge—A heavy momentary rush of current.
Surgical tape—A comparatively thick cotton webbing.
Switch—A device used to complete or interrupt an electric circuit.
Switch board—A panel of high insulation quality used to mount switches and instruments.
T—Symbol of torque, pound feet.
Tachometer—An instrument for indicating the revolutions per minute of a shaft by numerals.
Temperature—The degree of heat.
Terminal—That part to which leads are connected to or from.
Test—Apply conditions that will disclose the facts desired.
Thermal (cut-out)—A protective device for small loads that break the circuit by heat action upon a self contained element.
Third brush—On automobile generators, the brush that is movable and used to regulate the field current.
Time—The measure of duration.
Tooth—That part of laminations that separate two slots.
Torque—The turning effect.
Transmission line—A primary power line.

Transpose—To change from one side to the other. Reverse the order or change one with another.
Transformer—An apparatus used to change the potential of an electric circuit by magnetic induction.
Treated fabrics and papers—Treated with some substance to add to their insulating quality, usually oiled or varnished.
Trolley—An overhead wire or wires contacted by the machine it is feeding.
True—Being what it seems to be. Conforming to facts that are apparent.
Tubing insulating—See sleeving, spaghetti, also fibre.
Turbine—A wheel made up of many vanes driven by steam or some natural element.
Unit—A single thing by which contents may be compared or measured.
Universal—Adaptable to either alternating or direct current at its rated voltage.
V—Symbol of volume.
Vapor proof—Not affected by combustionable or deteriorating vapors.
Variable speed—A motor whose speed may be changed at will within its limits or range of speed.
Velocity—Rate of speed.
Vibrate—To move or swing back and forth.
Volt—The unit of electric pressure or electro motive force.
Voltage regulator—A device for controlling the electro motive force of a circuit. It may or may not be automatic.
Watt—Electrical unit of work.
Watt second—A product of watts and seconds.
Wave winding—A winding where the start and finish of each coil is some distance or many bars apart.
Wedge—A cut or fibre article shaped to fit in the slot of a rotor for retaining the winding in the slot.
Weight—Apparent force when gravity acts on mass.
Weld—To fuse together by heat.
Wheatstone bridge—An instrument used for measuring resistance.
Wire—A slender rod or filament of drawn metal.
Work—Energy expended to produce some definite result.
Wound rotor—Rotor whose winding is insulated from the lamination and designed to produce some particular effect.
Wye—See star.
X—Symbol of reactance.
Z—Symbol of impedance, ohm.
Zero—Nothing, nil.

Many of the new materials mentioned in the text of this book will not be readily available to you. We have gathered together a stock of all of the items mentioned, and if you have trouble finding them, we might suggest that you write to us for our price list. This is an added Autopower service to help you.

AUTOPOWER
ST. LOUIS, MO.